UST Remedial Investigation Work Plan Coaster's Harbor Island

Newport, RI

DEPARTMENT OF THE NAVY • UNITED STATES OF AMERICA •

Northern Division
Naval Facilities Engineering Command

Contract No. N62472-90-D-1298

Contract Task Order 0150

May 1994

Halliburton NUS
CORPORATION

5060-045-220

UST REMEDIAL INVESTIGATION WORK PLAN COASTER'S HARBOR ISLAND NEWPORT, RHODE ISLAND

COMPREHENSIVE LONG-TERM ENVIRONMENTAL ACTION NAVY (CLEAN) PROGRAM

Submitted to:
Northern Division
Environmental Branch, Code 18
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1.0 INTRODUCTION

1.1 BACKGROUND

1.1.1 General Facility Description

Coaster's Harbor Island (CHI) is located at the Naval Education and Training Center (NETC), in Newport, Rhode Island (Figure 1-1). CHI is situated just off the coast of Newport within Narragansett Bay and is connected to the mainland via two bridges. The island encompasses an area of approximately 0.2 square miles with approximately 80 to 90 percent of the island occupied by structures and paved areas

1.1.2 Site Background

CHI was acquired by the Navy in 1881 from the City of Newport to serve as a training center. In 1884, the Naval War College was established on the island. A causeway and bridge linking the island to the mainland was constructed in 1892. Various stages of expansion and structural development on CHI have occurr d during buildup of activities related with World Wars I and II and subsequent expansions of the Naval War College during the 1950's and 1970's (Envirodyne Engineers, 1983). The Naval War College is currently still active on CHI and the island is still much in use.

1.2 PROJECT DESCRIPTION

1.2.1 Project Background

During recent construction activity to upgrade the electrical distributing system on Coaster's Harbor Island, oil contaminated soil and groundwater were discovered in the vicinity of the old Fire Fighter Training Facility (FFTF). In addition, oil was found in an electrical manhole located some distance from the FFTF. The subject manhole was indicated to the HALLIBURTON NUS TEAM to be located adjacent to Structure 143 at the north end of CHI. The FFTF is currently being investigated under the Installation Restoration Program (IRP). It is unknown whether the contamination found in the manhole is related to the FFTF, or to some other source.

Structure 74, an oil storage reservoir centrally located on CHI, is considered to be a suspect or potential source of hydrocarbons released to the environment including the oil observed at the manhole and other areas on site. Figure 1-2 indicates the relative locations of Structure 74 and the subject manhole near Structure 143.

Structure 74, which consists of two (2) 282,000-gallon capacity fuel oil storage bunkers (in one structure), was constructed during 1917 as the fuel oil storage system for CHI. Structure 74 provides fuel to the CHI power plant (Structure 86) via a subsurface trench and piping system. The structure is rectangular in shape having approximate dimensions of 145 x 55 x 11 feet with a common wall separating both the north and south storage vaults. The structure was constructed with reinforced concrete used in the floor slab,

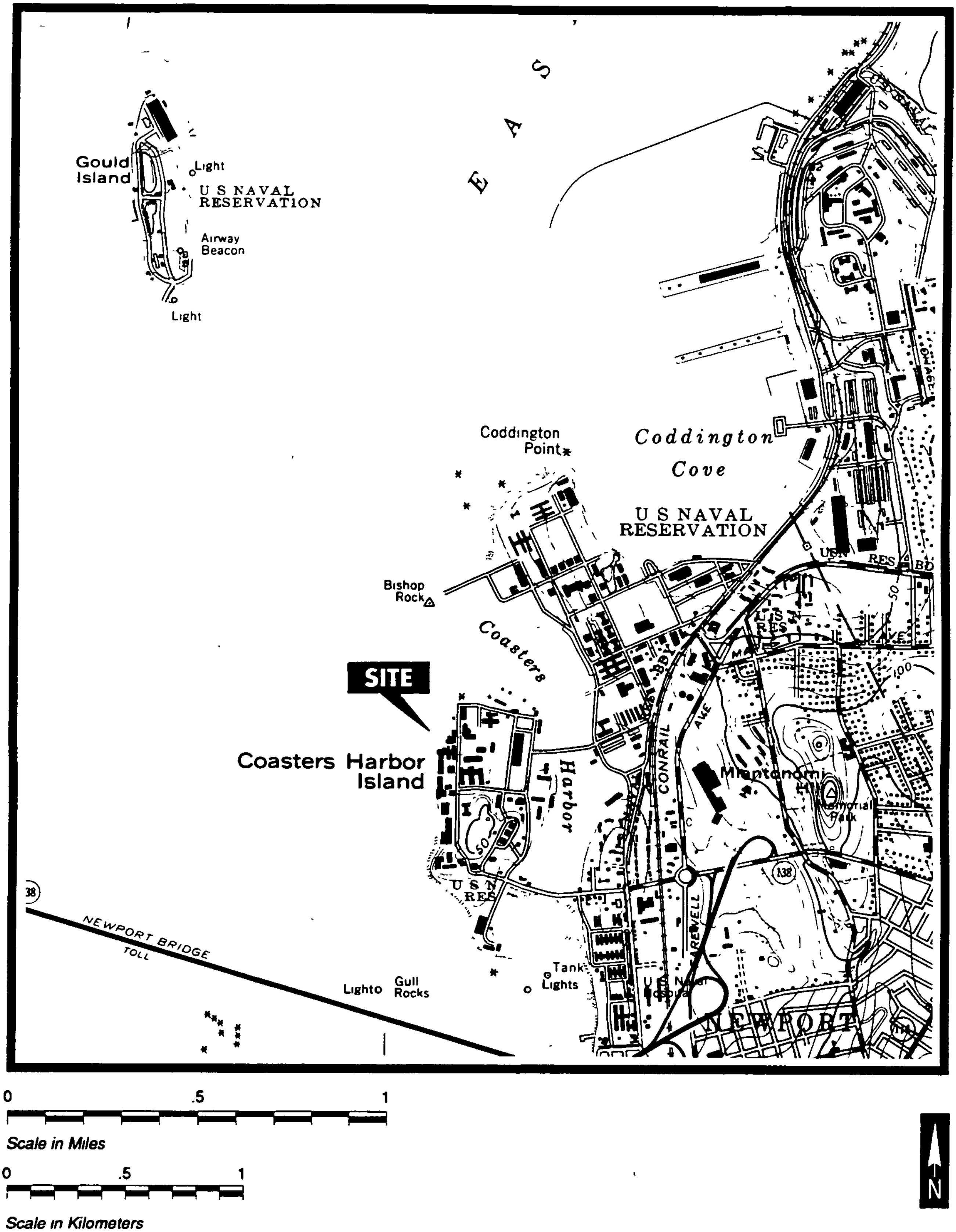

FIGURE 1-1

SITE LOCATION MAP - COASTERS HARBOR ISLAND

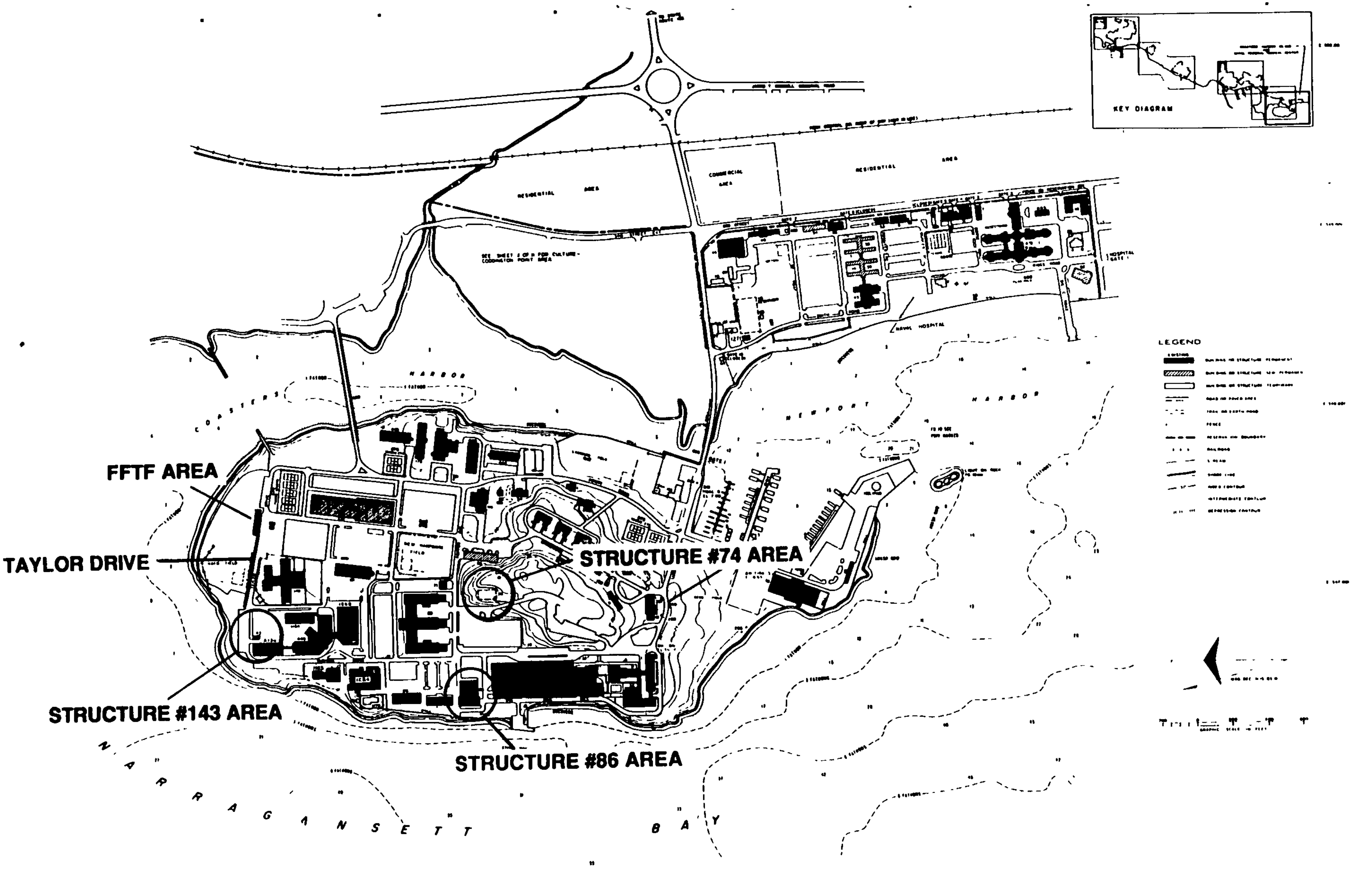

FIGURE 1-2
PROJECT LOCATION - COASTERS HARBOR ISLAND

walls and ceiling. According to the original plan specifications, four (4) inches of reinforced concrete is present in the floor slab and eight (8) inches of reinforced concrete is present in the walls and ceiling No information on original structural linings or coatings for the concrete surfaces were noted on the drawings.

From the time of construction through most of 1988, No. 6 fuel oil was used as the fuel source delivered to Structure 74. The fuel type was converted to No. 4 fuel oil in November, 1988. This type of fuel oil is presently still being used on site. Product delivery totals were obtained from NETC for the period 1986 through 1990. For the three (3) year period between 1986 and 1988, deliveries of No. 6 fuel oil amounted to an average of 3.70 million gallons of oil each year. In 1989, when fuel usage was converted from No. 6 to No. 4 oil, the fuel delivery total was approximately 3.28 million gallons. The 1990 fuel delivery total was approximately 2.02 million gallons. Fuel delivery totals for 1991 based from daily delivery records indicate a total of approximately 5.30 million gallons consumed. Without further evaluation, it is not known why annual fuel usage has varied so much over the last five years for which records have been reviewed.

In April of 1989, an oil spill incident report was filed by NETC which indicated that a release of approximately 200 gallons of No. 4 residual heating oil had occurred with the spill source list d as discharge from Structure 74. The incident was initiated by observations of fuel oil in an oil/water separator located adjacent to Structure 86 followed by observations of seepage into an underground valve station and piping trench next to Structure 74. NETC personnel determined that leakage was occurring from the south tank and responded by evacuating the tank within 24 hours which stopped leakage into the trench. Rhode Island Department of Environmental Management (RIDEM) was notified regarding the incident and discussions were initiated relative to investigation of the extent of environmental impact.

In August of 1989, four (4) four-inch diameter PVC monitoring wells were installed within approximately 50 feet of the north and west sides of Structure 74. Three (3) of the four wells encountered bedrock at depths of approximately 10 feet or less without encountering ground water. The remaining well (MW-2) intercepted ground water with an indication that free product was also present.

In September of 1989, Tracer Research Corporation (TRC) was contracted by NETC to perform leak testing of Structure 74. A leak testing method was developed specifically for use at this site but was not implemented at this time because of the known leakage incident. Leak testing was postponed until tank repairs were completed.

In October of 1989, the interior of Structure 74 - south tank was inspected by NETC personnel prior to repairs. A 25-foot long crack in the concrete floor was observed to be present and actively seeping inward. Contractors installed a small floor drain and pump in an effort to stop the seepage so the crack could be repaired. Once seepage was controlled from the floor crack, the records indicate epoxy was used to s al it.

In December of 1989, a blended latex membrane liner with reinforcing fabric was epoxied in place. The south tank was later placed back into service. The north tank was similarly lined a short time later. Total liner thickness is estimated to be approximately 40 ml (minimum thickness) according to installation specifications.

In January of 1990, tank leakage testing was initiated to Tracer Research Corporation. The testing procedure involved injection of two gallons of a tracer substance into the south tank, followed by injection of air into exterior probes along the east side of Structure 74, and collection and analysis of air samples from probes placed along other sides of the tank structure. The test was also repeated in the reverse direction. The testing indicated the presence of very low concentrations of tracer substance in some of the samples. A leakage rate of .0032 gallons per day was calculated by TRC. Because of the low leakage rate, assumed to be approximately one (1) gallon per year, TRC certified the tank as not leaking and recommended periodic monitoring to determine liner performance over time.

Intermittent monitoring of oil and water levels in TRC probes by NETC personnel between October, 1989 and January, 1990 indicated the reduction of oil in some probes but an increase in oil in others. NETC personnel noted that three (3) of nine (9) TRC probes (#1, 2, 4) were not functioning on 1/8/90. Sixty (60) percent of the probes were assumed to be present and functioning at the time of the TRC leak test on 1/20/90, according to NETC records. It is not known whether the probes were reinstalled prior to the leak test or exactly what the indicated functioning problem was.

The south tank was fully returned to service in January, 1990. The north tank was briefly taken out of service in early 1990 to allow for liner installation. Facility records indicate that the fuel delivery piping between Structure 74 and Structure 86 (Power House) was replaced in 1989.

In addition to the environmental investigations planned for Structure 74 and the Structure 143 manhole area, the Navy has requested an investigation of an abandoned fuel oil line between Structure 86 and the vicinity of Structure 143. Construction details of the fuel oil line appear on a plan dated April 28, 1944, titled "Naval Training Station Newport R.I., Large Ship Pre-commissioning Training Center, Engine Training Bl'd'g & School, Fuel & Diesel Oil Supply Blow-down Tank." The fuel oil line ran inside of a steam trench and delivered fuel oil from Structure 86 (the power plant) to the Engine Training Building located wh re Structure 138 now stands. The fuel line was abandoned at an unknown date and some sections have been excavated and removed.

1.2.2 Project Objectives

The objective of this field program is to identify and investigate potential sources of hydrocarbon contamination on Coaster's Harbor Island. The areas of investigation are limited to the vicinity of Structure 74, the electrical distribution system manhole area located next to Structure 143 and along Taylor Drive, and the abandoned fuel oil line between Structure 86 and the vicinity of Structure 143. Except for MW-5, near the middle of Taylor Drive, the FFTF area itself will not be included within this investigation program as it is being investigated under separate contract by others. The overall purpose of the investigation program is to determine the extent of contamination in the area of Structure 74, the area along Taylor Drive including the manhole next to Structure 143, and the path of the abandoned fuel oil line, evaluate available r medial alternatives, and ultimately, to allow for selection of the best available remedial technology for the affected areas.

1.3 PROJECT DELIVERABLES

Project deliverables will include submission of the underground storag tank Remedial Investigation (UST RI) Report. The UST RI Report will include the following information: summary of project background information, a thorough description of the field investigation program activities, summary of hydrogeologic conditions, evaluation of analytical data for laboratory submitted and field analyzed samples, and relevant conclusions and recommendations. The UST RI Report will be supported with appendices which provide copies of boring logs, well completion reports, sample collection records, and a complete copy of the laboratory data package. A site plan will also be presented which depicts boring and well locations within each investigation are.

1.4 REGULATORY OVERVIEW

RIDEM has issued new regulations (June 30, 1992) for underground storage facilities which use petroleum products and hazardous materials. These regulations contain requirements for registration of storage faciliti s with the State, requirements for facility modifications and upgrades and leak and spill response, site investigation report requirements, and Corrective Action Plan requirements. The new regulations supersede an earlier version previously issued in 1986.

1.5 WORK PLAN ORGANIZATION

Section 2.0 of this Work Plan provides the Site Management Plan (SMP); Section 3.0 provides the Field Sampling Plan (FSP), and Section 4.0 the Quality Assurance/Quality Control Plan. Various appendices are also included which provide a table of common acronyms (Appendix A), the site Health and Safety Plan (Appendix B), copies of pertinent HALLIBURTON NUS Standard Operating Procedures (Appendix C), a Task Modification Request form (Appendix D), the sample collection equipment list (Appendix E), and copi s of sample control documentation (Appendix F).

2.0 SITE MANAGEMENT PLAN

The Site Management Plan (SMP) primarily outlines the overall project organization for the field investigations, in addition to the identification of key personnel and their responsibilities. The SMP also details site access, security, and control to be exercised during the field investigations. A detailed project schedule for the start-up, implementation, and reporting of field activities is also presented in this section

2.1 SITE CONTROL

The following sections summarize the procedures to be implemented during the field activities.

2.1.1 Site Access

Access to the CHI is controlled at the pass office located adjacent to Gate 1 on CHI. Once on CHI, access to each sampling location is unrestricted. A facility water supply source will be made available on CHI so that potable or operations-related water does not need to be transported onto the Island. Sanitary facilities will be made available within buildings located near each activity area.

Ten working days prior to commencing field activities, the HALLIBURTON NUS Team Project Manager (PM) shall notify the Navy Northern Division Remedial Project Manager (RPM), Mr. Brian Helland (tel. 215-595-0576), and obtain verbal authorization to begin. Immediately after the Navy's authorization, the Field Team Leader (FTL) shall notify the Environmental Officer at CHI, Lt. Jeff Borowy (tel. 401-841-3735), the Activity Point of Contact (POC), prior to commencing activities on the site.

No HALLIBURTON NUS Field Team personnel shall perform work at the Activity until: (1) written or verbal authorization is obtained by the PM, (2) at least 10 days notice is given to the RPM, and (3) at least 24-hour notice is given to the Activity POC, and (4) each Field Team member has personal identification in the form of a driver's license or company identification card.

2.1.2 Site Security/Control

As discussed above, access to the Activity is restricted via Gate 1 and passes are required before accessing CHI. The HALLIBURTON NUS Field Team will augment security by conducting their activities from a secure vehicle. All sampling equipment and other field supplies will be maintained in the vehicle, and the Field Team shall collect all supplies and equipment into the vehicle prior to each departure from each site.

2.1.3 Field Office

Due to the brief field time anticipated for this project, a van-type vehicle will be used as the Field Office. The van will serve as a central command post through the duration of the field work, providing shelter, offic space, and space for equipment storage and sample handling. A cellular transportable telephone will be used for communications. Sanitary facilities are available on CHI and will be specifically identified by the POC.

2.2 PROJECT ORGANIZATION AND RESPONSIBILITIES

The HALLIBURTON NUS Team will be responsible for the overall management and conduct of the field investigation activities covered by this Work Plan. The sections that follow present the names and organization of the key personnel connected with the field work. Navy personnel will be actively involved in any coordination between state and federal regulatory agencies and the HALLIBURTON NUS Team while onsite.

2.2.1 Organization

The key personnel connected with this project, their respective organizations and the chain of communications follow.

- Northern Division
  Naval Facilities Engineering Command
  10 Industrial Highway
  Mail Stop #82
  Lester, PA 19113-2090
  (215) 595-0567

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  Engineer in Charge
  Technical Point of Contact

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  (401) 841-3735

  Lt. Jeff Borowy Environmental Officer
  Activity Point of Contact

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  (610) 971-0900

  John Trepanowski
  Program Manager

- ENSR Consulting and Engineering (HALLIBURTON NUS Team member)
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  Acton, MA 01720
  (508) 635-9500

  Larry Pannell
  Project Manager (PM)

  Jeanette Junod
  Field Team Leader (FTL)

  Laurie Ekes
  Quality Assurance/Quality Control Advisor

  Kathy Harvey
  Company Health and Safety Officer (CHSO)

Th PM serves as the HALLIBURTON NUS Team Point of Contact and has the primary responsibility for the management and conduct of the work. She is responsible for the coordination of all onsite personnel and for providing technical assistance for all activities that are directly related to the determination of the environmental quality of the site. The review of all environmental data will be conducted by the PM or her designee. If quality assurance issues requiring special action are identified, the PM and the Project QA/QC Advisor will identify the appropriate corrective action.

All field work will be performed by a two to three person team composed of the FTL, and one or more Environmental Scientists, one of whom will also serve as the Site Safety Officer (SSO). The FTL will direct and participate in all field activities, and will report directly to the PM. The SSO will report directly to the Company Health and Safety Officer (CHSO) relative to safety matters. A project organization chart depicting the individuals involved in the management and field activities for this investigation are presented in Figure 2-1.

2.2.2 Responsibilities

Key personnel for field operations and their specific responsibilities are discussed below.

Field Team Leader (FTL). The FTL is responsible for all day-to-day aspects of the field work. The responsibilities of the FTL include:

- Assuring that all field team members are familiar with this document; ultimate responsibility for field operations, quality control, and documentation.

- Providing team members with daily assignments.

- Assuring that all field team members have completed health and safety training.

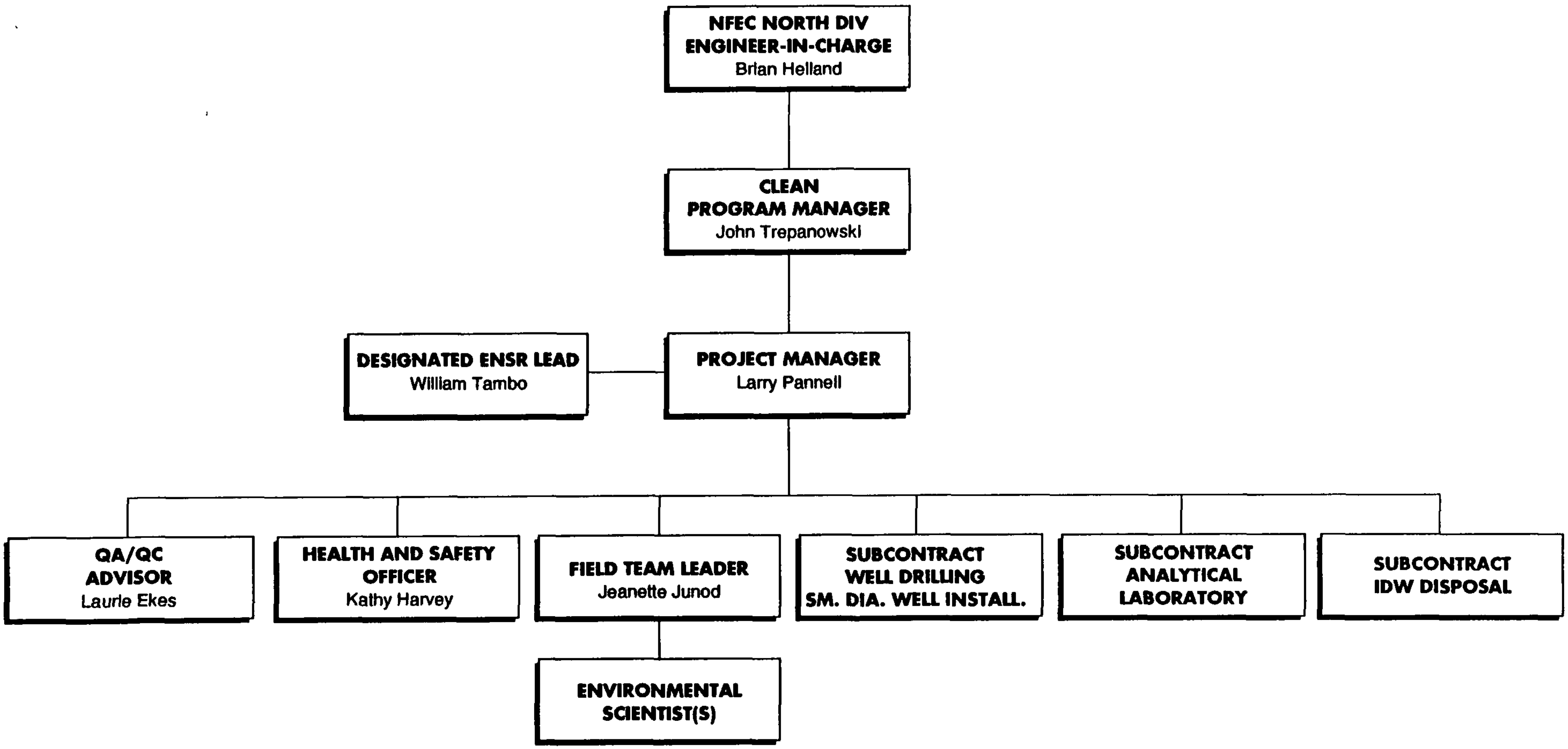


FIGURE 2-1

HALLIBURTON NUS TEAM PROJECT ORGANIZATION CHART - COASTERS HARBOR ISLAND

- Reporting to the Project Manager on a regular basis regarding th status of all field work and any problems encountered.

- Completing the site logbook on a daily basis.

- Completing Task Modification Requests (TMRs), as necessary, for approval by the Project Manager. A TMR is provided in Appendix D.

- Advising and monitoring the on-site subcontractor drilling operations. Completing boring logs as necessary.

- Assuring that team members comply with the procedures outlined in the SAP, particularly documenting the borings and soil sampling activities.

- Ensuring sample documentation and shipping requirements are met.

- Coordinating with Activity personnel to assure access to the site.

- Ensuring that mobilization and demobilization at the site is complete, especially the collection, containment and labelling of investigation derived wastes (IDW) and used personal prot ctive equipment (PPE).

Site Safety Officer (SSO). The SSO reports to the Company Health and Safety Officer (CHSO) and indirectly to the FTL, PM, CLEAN Health and Safety Manager (CHSM). Details of the SSO's responsibilities are presented in the HASP and include:

- Controlling specific health and safety-related field operations such as personnel decontamination, monitoring of worker heat or cold stress, distribution of safety equipment, etc.

- Conducting and documenting a daily Health and Safety briefing each day while on site.

- Assuring that Field Team personnel comply with all procedures established by the HASP.

- Identifying Assistant SSOs or SSO designees in his absence.

- Terminating work if an imminent safety hazard, emergency situation, or other potentially dangerous situation is encountered

- Assuring the availability and the condition of health and safety monitoring equipment.

- Coordination with the FTL and PM to institute and document any HASP modifications.

- Ensuring that Activity personnel and U.S. Government Contractors are adequately advised and kept clear of potentially contaminated materials.

Environm ntal Sci ntist. The environmental scientist reports to the FTL and the SSO. Details of this p rson's responsibiliti s include:

- Proper conduct of all sampling activities.

- Proper completion of boring logs, well completion records, field data sheets, sample labels and chain-of-custody records.

- Sample equipment decontamination.

- Reporting to the FTL on a regular basis of the status of borings and other sampling activities.

2.3 SCHEDULE

The primary target dates connected with the field activities follow (overlapping dates indicate that multiple subtasks are occurring simultaneously):

- Subcontractor specifications preparation - May 2 - July 5, 1994

- Field preparation - June 13 - July 25, 1994

- Field Sampling - July 11 - November 7, 1994

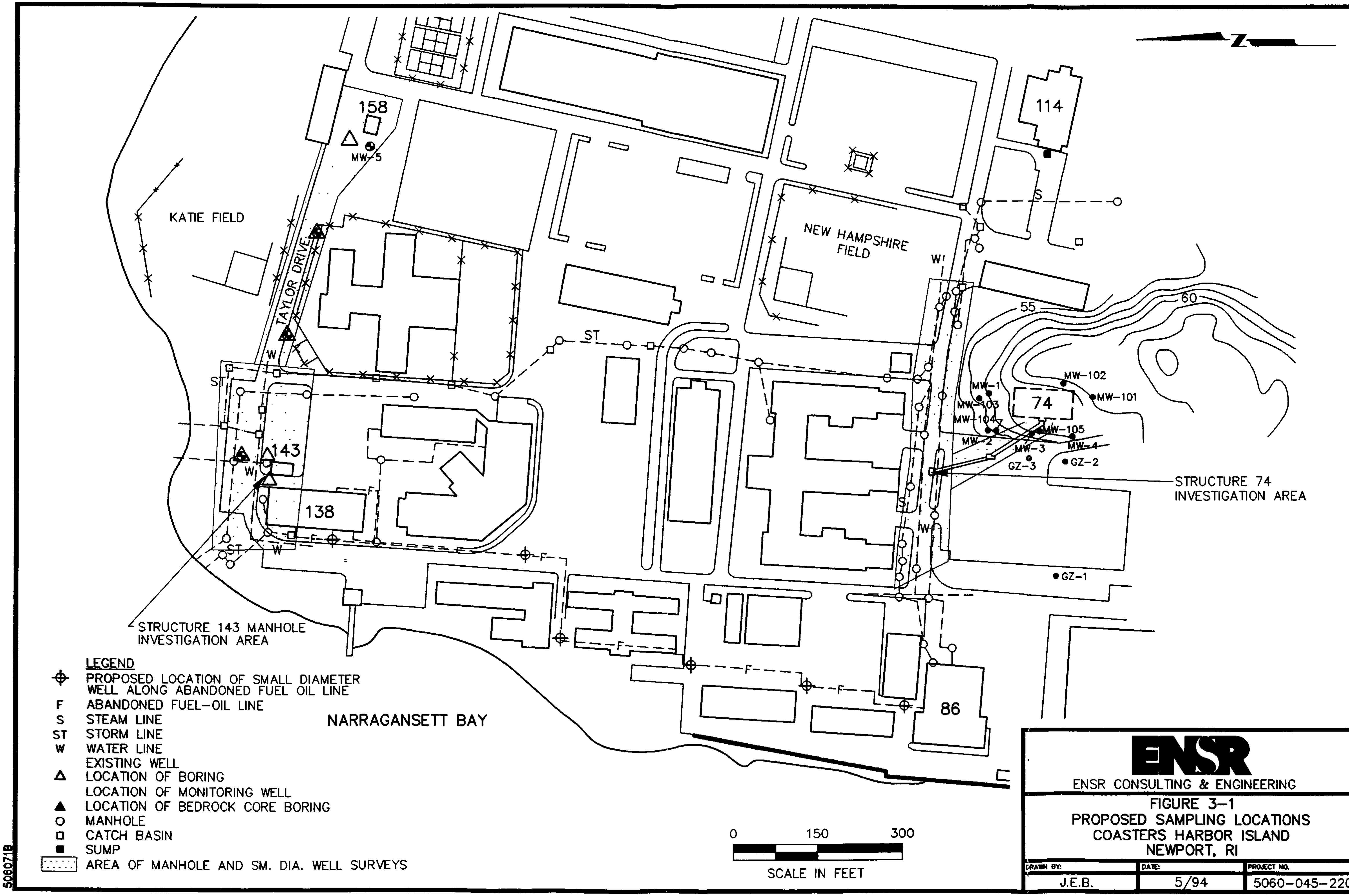
The target dates for project milestones and deliverables are as follows:

- RI Report Rough Draft - January 20, 1995

- RI Report Draft - February 3, 1995

- RI Report Final - March 31, 1995

These dates and activities are shown on Figure 2-2, the detailed project schedule.



KATIE FIELD
TAYLOR DRIVE
158
MW-5
114
NEW HAMPSHIRE FIELD
55
60
MW-102
MW-1
MW-101
MW-103
74
MW-104
MW-105
MW-2
MW-3
MW-4
GZ-3
GZ-2
GZ-1
STRUCTURE 74 INVESTIGATION AREA
143
138
86
STRUCTURE 143 MANHOLE INVESTIGATION AREA
NARRAGANSETT BAY
LEGEND
PROPOSED LOCATION OF SMALL DIAMETER WELL ALONG ABANDONED FUEL OIL LINE
F ABANDONED FUEL-OIL LINE
S STEAM LINE
ST STORM LINE
W WATER LINE
EXISTING WELL
LOCATION OF BORING
LOCATION OF MONITORING WELL
LOCATION OF BEDROCK CORE BORING
MANHOLE
CATCH BASIN
SUMP
AREA OF MANHOLE AND SM. DIA. WELL SURVEYS
0 150 300
SCALE IN FEET
N
ENSR
ENSR CONSULTING & ENGINEERING
FIGURE 3-1
PROPOSED SAMPLING LOCATIONS
COASTERS HARBOR ISLAND
NEWPORT, RI
DRAWN BY: J.E.B.
DATE: 5/94
PROJECT NO. 5060-045-220
50607IB

3.0 FIELD SAMPLING

The Field Sampling Plan (FSP) provides the HALLIBURTON NUS Field Sampling Team (Field Team) with the overall direction and techniques necessary to meet the objectives of the field sampling program. General field procedures to be used by the Field Team during the activities are presented in the appended HALLIBURTON NUS Operating Procedures (SOPs), contained in Appendix C. The objectives of the activities and the sequence of the tasks and procedures making up each of the activities are presented below.

3.1 SITE BACKGROUND

Sp cific site background information is presented in Section 1.0 of this Work Plan. Additional information on site physiographic conditions is presented in the following paragraphs.

3.1.1 Site Physiographic Conditions

Coasters Harbor Island lies off the coast of Newport, Rhode Island within Narragansett Bay. The island is roughly oval in shape and is approximately .7 miles long by .3 miles wide with the long axis treading northward. Vertical relief totals approximately 65 feet with the island's highest point being south-centrally located. Bedrock, which consists essentially of a coarse-grained conglomerate (Rhode Island Formation) outcrops at several locations within the center of the island. Bedrock is assumed to be shallow at most locations on the island and was the controlling influence in shaping the island during the last period of glaciation. Unconsolidated materials above the bedrock surface, from review of site information, consist of glacial till, sand and gravel, silt and organic muck. Approximately 80 to 90 percent of the island is developed and covered by pavement or structures.

Ground water is indicated to be presented at shallow depths of approximately 5 feet along coastal areas where monitoring wells are present (FFTF area) and at depths of greater than 10 feet inland (near Structure 74). Fresh ground water is likely to be limited in supply with rainfall infiltration the principal means of replenishment. Rainfall runoff is controlled over much of the island, however, with storm runoff directed through storm drains into the Bay. No ground water supply wells have been indicated to be present on Coaster's Harbor Island.

3.2 SAMPLING OBJECTIVES

The general objective of this sampling program is to determine the extent of hydrocarbon releases in the vicinity of Structure 74, the manhole located adjacent to Structure 143 and along a section of Taylor Drive between Structure 143 and the FFTF investigation area, and along the abandoned fuel oil line between Building 86 and the vicinity of Structure 143. The anticipated source of much of the contamination in the vicinity of Structure 74 and the manhole adjacent to Structure 143 is suspected to be Structure 74, therefore, one purpose for these investigations is to determine the major routes of transport or migration of hydrocarbons from this structure, as well as to define the extent of release around the perimeter of this structure. It is not known whether the hydrocarbons observed within the manhole located next to Structure 143 are related to Structure 74 or to some other area; ther fore, one other purpose for these investigations is to try and determine wh ther both ar as of contamination are r lat d to one another. Ultimately, upon completion of the field investigation program, sufficient information will have been gathered to allow for evaluation of available remedial action alternatives for control of hydrocarbon contamination and sel ction of the best available technology which is both feasible and economical in providing effective remediation for this site.

It should be noted that this Work Plan presents a scope of work which is somewhat limited in nature, in that the proposed investigation work is confined to the immediate area surrounding Structure 74, the manhole near Structure 143 and along Taylor Drive and the abandoned fuel oil line between Building 86 and the vicinity of Structure 143 which are located some 1400 feet to the north. In order to define a limited and economical investigation program such as this, and also fulfill the program objectives, certain assumptions have been made. These assumptions are as follows:

- Given the possibility that Structure 74 is the source for hydrocarbons observed within the manhole area, the major route for contaminant transport is likely to be through gravitational flow along buried utility trenches within their coarse and permeable backfill and also, to an unknown extent, natural gradient transport along the water table within the unconsolidated materials found on the island. Bedrock contaminant transport is also a possibility. A limited evaluation of this likelihood will be made based upon the results of the sampling program.

- Even though the integrity of Structure 74 has been improved via installation of a liner within both halves of the structure (south and north tanks), it is assumed that a contaminant source still remains within the vicinity of the structure. Potential sources of hydrocarbon contamination could consist of: residual product accumulations within Structure 74 backfill materials (i.e., granular fill under floor slab or around sides) and residual product within other subsurface areas such as nearby utility trenches and surrounding soils and bedrock. With installation of the liner, it is assumed that no further leakage through the structure is occurring.

It should be noted that limiting investigations to the vicinity of these areas may not completely define the extent of hydrocarbon contamination on CHI. Activity personnel have indicated hydrocarbon detections have occurred in other areas of the island. If Structure 74 is a potential source for these other hydrocarbon observations, then additional investigations may be required at a later date to evaluate other areas on the island. The need for additional investigations would be driven by RIDEM requirements, if any, following review of the UST RI report for this investigation. One possible outcome of this investigation would b to determine the need for additional studies, if for instance, hydrocarbons are found to be widespread. Long term ground water monitoring, if required by RIDEM, may be conducted with the use of monitoring w lls installed during this investigation program.

3.3 SAMPLE LOCATIONS AND FREQUENCY

Environmental sampling will be conducted in three areas on CHI: (1) in the vicinity of Structure 74, (2) along Taylor Drive between Structures 143 and 158 including the vicinity of the electrical manhole previously mentioned, and (3) along the abandoned fuel oil line between Building 86 and the vicinity of

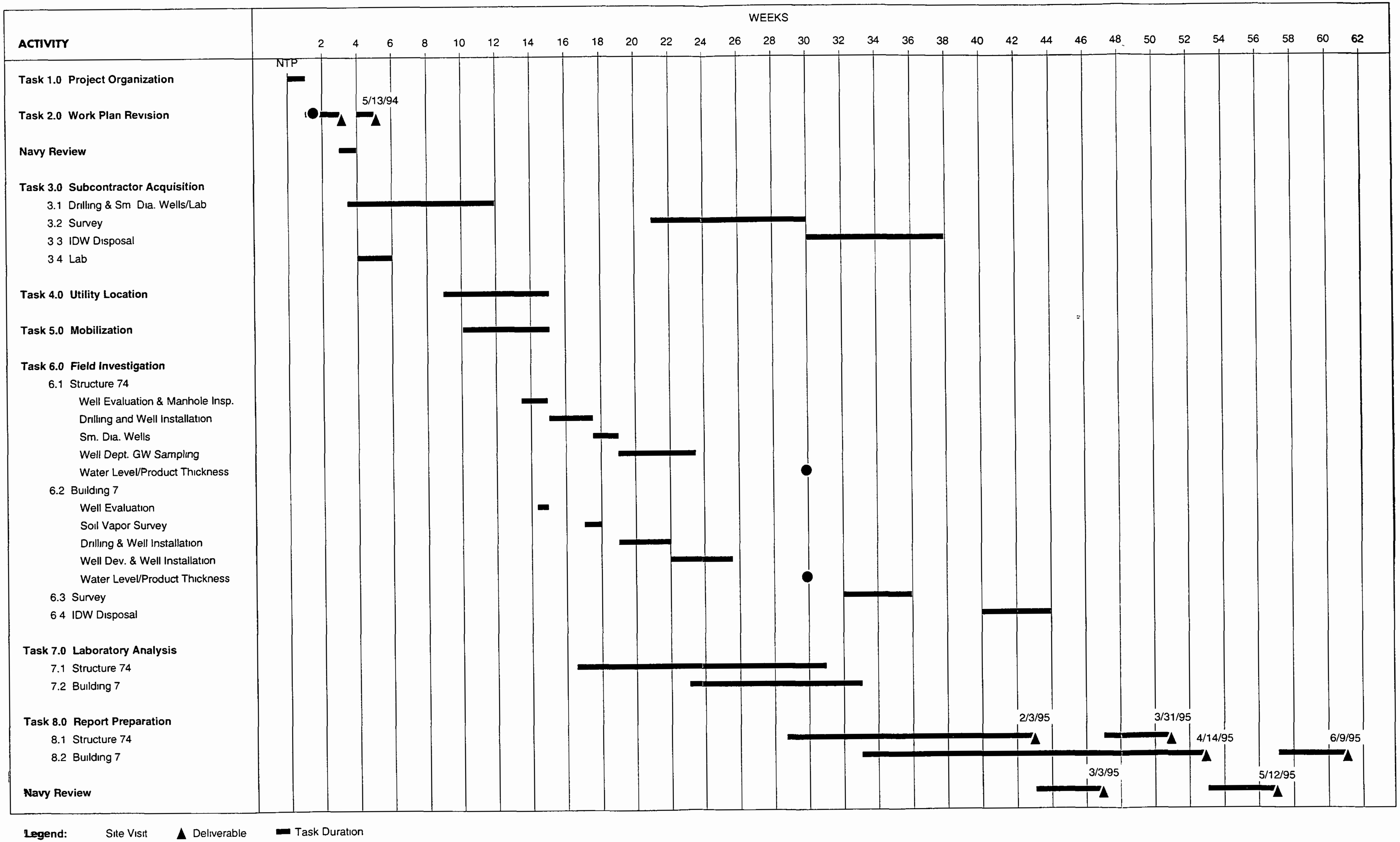


FIGURE 2-2
PROJECT SCHEDULE NETC NEWPORT

Structure 143 (se Figure 3-1). The following typ s of activiti s will be conducted in ach investigation area:

Structure 74

- Manhole inspection in nearby utility trenches for presence of hydrocarbons. Sediment and surface water samples will be collected for TPH analysis if hydrocarbons are visibly present.
- Small-diameter well installation within the utility trench backfill materials to determine the presence of hydrocarbons.
- Groundwater sampling and analysis of the new small-diameter wells (for TPH) and the existing conventional monitoring wells (for TPH, TCL VOC, TCL SVOC and RCRA 8 metals).
- Elevation survey of the new groundwater sampling points for development of water table contour maps.

Structure 143 Manhole and Taylor Drive

- Manhole inspection in nearby utility trenches for presence of hydrocarbons. Sediment and surface water samples will be collected for TPH analysis if hydrocarbons are visibly present.
- Small-diameter well installation within utility the trench backfill materials to determin the presence of hydrocarbons.
- Overburden soil borings and well installations for groundwater monitoring purposes.
- Soil boring sample analysis for TPH to determine hydrocarbon concentrations.
- Groundwater sampling and analysis of the new small-diameter wells (for TPH) and the new and existing conventional monitoring wells (for TPH, TCL VOC, TCL SVOC and RCRA 8 metals).
- Elevation survey of the new groundwater sampling points for development of water table contour maps.

Abandoned Fuel Oil Line between Building 86 and Structure 143

- Small-diameter well installation within the utility trench backfill materials to determine the presence of hydrocarbons.
- Groundwater sampling and analysis of the new small-diameter wells for TPH.
- Elevation survey of the new groundwater sampling points for development of water table contour maps.

Additional information regarding the specific number and types of activity to be conducted in each area is presented in the following paragraphs:

3.3.1 Structure 74 Activities

Figure 3-1 indicates the approximate locations for the sampling points within the vicinity of Structure 74. The indicated locations may be adjusted slightly in the field as a result of actual site conditions.

Manhole Insp ction

Existing site plans indicate the following buried utilities to exist on CHI: st am service lines, storm drains, sanitary sewer, water mains, and buried electrical service in some areas. Occasionally, hydrocarbons, which may be present within trench backfill materials, will find their way into the utility line itself. Therefore, a simple determination of hydrocarbon contamination can sometimes be made via manhole inspection. HALLIBURTON NUS Team will identify and open accessible manhole or storm drain covers for each utility which is found to be within an approximate 400 foot radius of Structure 74. The interior of the manhole structure will be inspected for visible hydrocarbons and hydrocarbon odors. The findings of this survey will be noted in the field logbook and on facility drawings. If visible hydrocarbons are indicated, representative samples of sediment and/or water will be obtained for total GC fingerprinting by GC/FID method as outlined in Section 4.7 of this work plan (Section 4.7 - GC/FID). No other environmental samples are planned for coll ction as part of this task.

Existing Well Evaluation

The xisting wells installed around the vicinity of Structure 74 will be examined to verify well location, well integrity, and the presence of water and/or product. The results of the existing well evaluation will be used to determine which existing wells will be selected for groundwater sampling.

Small Diameter Well Installation - Utility Trenches

Small diameter wells (5/8 inch I.D.) are designed for installation in confined areas. These wells are installed with a portable vibratory drilling machine which drives the well point directly into the ground surface to th required depth. This drilling method is faster than conventional drilling and is most often used for investigating contaminant sources and searching for contaminant boundaries. Small diameter wells are generally not used for long term monitoring but can be installed with protective well caps for this purpose.

Small diameter wells will be installed at up to 10 locations primarily along the steam service utility trench (Porter Ave) and the storm drain line located north of and perpendicular to Porter Ave. The wells will be installed within the trench backfill materials for the purpose of determining whether hydrocarbon accumulations are present within the backfill, and if so, determine its lateral extent. Well completion depths will average between four (4) and six (6) feet and is dependent on the actual depth of each utility line (d pth determined from review of utility plans and available inspection survey). A water level or hydrocarbon determination will be made immediately upon installation. If no liquids are present the w lls will be removed. Wells which contain liquids will be completed as permanent installations, and sampled.

Well Development

The small-diameter wells will be developed immediately after installation. The purpose of well development is to remove silt and other fines which settle in the vicinity of the well screen and at the bottom of the well during installation. Well development will be accomplished by purging the well of silty water using a peristaltic or inertia pump. Development will continue until the purge water is as silt-free as possible and all fines have been removed from the bottom of the well. Purge water which contains no visible hydrocarbons will be discharged to the ground surface in the vicinity of the w ll. Purge water which contains visible hydrocarbons will be collected by th fi ld team and transported to a bulk container located at the staging area els where on-site.

Ground Water Sample Analysis

Groundwater samples will be obtained from each of the small-diameter wells which encountered water (assumed to be 10) and 11 of the existing conventional wells already present in the vicinity of Structure 74. The specific existing wells to be sampled will be determined in the field based on which wells contain water and their location relative to Structure 74 and each other. The objective will be to sample existing w lls which will provide broad coverage of the area surrounding Structure 74, as opposed, for example, to sampling all the wells on only one side of the structure. One groundwater sample will also be collected from a sump located at Structure 114 where hydrocarbons were once observed during construction.

The samples collected from the small-diameter wells and the sump will be analyzed for TPH as described in Section 4.7 - GC/FID method. The samples collected from the conventional monitoring wells will be analyzed for TPH, TCL VOC, TCL SVOC and RCRA 8 metals. Additional QA/QC samples will be collect d and analyzed at the frequency specified in Section 4.7.

If sufficient free product is present in any well (conventional or small-diameter), a product sample will be obtained instead of a groundwater sample and will be analyzed for TPH by GC/FID method only.

Water Level and Product Thickness Measurements

Water level and product thickness measurements will be made in all new and existing wells approximately 5 weeks after well sampling is complete. The data will be used to develop water table elevation contour maps and to delineate the extent of any free product found.

Elevation Survey

Measuring point elevations will be obtained from each new monitoring well which will be used for wat r tabl measurements as a quality assurance check. One of the existing wells to be used in the round of water level measurements will also be surveyed for elevation in order to compare the results with established data. All measuring points will be referenced to a common datum (assumed to be N.G.V.D.) and measured to the nearest .01 feet. These measurements obtained during the ground water sampling tasks will be used to generate a ground water contour map. Water level measurements will allow for determination of depth to ground water and ground water flow direction within the vicinity of Structure 74. Surveying of measuring point elevations will be conducted by a registered land surveyor licensed to practice in the State of Rhode Island, subcontracted by HALLIBURTON NUS.

3.3.2 Structure 143 Manhole and Taylor Drive Activities

Figure 3-1 indicates the approximate locations for the sampling points to be completed along Taylor Drive between Structure 143 and 158. The indicated locations may be adjusted slightly in the field as a result of actual site conditions.

Manhole Inspection

As with th other investigation area, all acc ssible utility manholes and/or storm drains will be inspected within a 400 foot radius of the Structure 143 manhole and along Taylor Drive to Structure 158 and the findings will be documented within the field logbook and applicable facility drawings. Representative samples of sediment and/or water will be obtained if petroleum hydrocarbons are indicated (Section 4.7 - GC/FID method).

Overburden Soil Borings/Well Installation

A total of six (6) soil borings will be completed within this investigation area. Three (3) soil borings will be completed within the vicinity of the manhole near Structure 143 for the purpose of determining whether hydrocarbons are present at the water table interface. Two (2) of these borings will be completed to a depth of no greater than 10 feet into the water table. The third boring will be completed to a point of r fusal which is anticipated to be bedrock surface and assumed to be within 30 feet of the ground surface. Thre (3) additional borings will be completed at approximate 150-foot intervals along Taylor Drive. These borings will be completed to a maximum depth of 15 feet.

Three (3) monitoring wells will be installed within this activity area. Each monitoring well will be installed in completed borings at the water table for ground water quality and water level monitoring purposes. Thes wells will supplement information from wells which already exist in the nearby FFTF area. Those borings which will not include well installation will be filled and grouted up following completion of the sampling program.

Small Diameter Well Installation - Utility Trenches

Five (5) small diameter wells will be installed within utility trench backfill primarily along the storm drains which runs in a north-south direction east of Structure 143. Well completion depths will average betw n four (4) and six (6) feet below ground surface. These sampling points will determine whether hydrocarbons are present within trench backfill materials. Sampling points which encounter free liquids (hydrocarbon and/or water) will be completed as permanent installations.

Soil Boring Sample Analysis

A maximum of six (6) soil samples (one per boring) will be retained and submitted for laboratory analysis for th purpose of determining the presence and concentration of hydrocarbons. Samples to be submitt d for laboratory analysis will be selected based on field observation and HNu response. The samples will be analyzed for total petroleum hydrocarbons (Section 4.7 - GC/FID method). No quality assurance soil samples will be obtained within the Structure 143/Taylor Drive inspection area.

W ll Development

The conv ntional monitoring w lls will be developed approximately one week prior to sampling. The purpose of well development is to remove silt and other fines which settle in the sand pack and at the bottom of the well during well installation. Well development will be accomplished by alternately surging the well with a surge block and purging the silty water with a pump until the purge water is as silt-free as possible and all fines have been removed from the bottom of the well.

The small-diameter wells will be developed immediately after installation. Because they are driven and have a small-diameter, they require less development and produce less purge water. Purge water from the conventional and small-diameter wells which contains no visible hydrocarbons will be discharged to the ground surface in the vicinity of the well. Purge water which contains visible hydrocarbons will be collected by the field team and transported to a bulk container located at the staging area on-site.

Ground Water Sample Analysis

Groundwater samples will be obtained from each of the small-diameter wells which encountered water (assumed to be 5), the 3 new conventional monitoring wells and from existing well MW-5 locat d by Building 158.

Th samples collected from the small-diameter wells will be analyzed for TPH as described in Section 4.7 - GC/FID method. The samples collected from the conventional monitoring wells will be analyzed for TPH, TCL VOC, TCL SVOC and RCRA 8 metals. Additional QA/QC samples will be collected and analyzed at the frequency specified in Section 4.7.

If sufficient free product is present in any well (conventional or small-diameter), a product sample will be obtained instead of a groundwater sample and will be analyzed for TPH by GC/FID method only.

Water Level and Product Thickness Measurements

Water level and product thickness measurements will be made in all new and existing wells approximately 5 weeks after well sampling is complete. The data will be used to develop water table elevation contour maps and to delineate the extent of free product found.

Elevation Survey

As with the other investigation area, the monitoring wells and small diameter well sampling points will b surveyed to allow for accurate monitoring of water levels. A survey datum common to that used for the existing FFTF wells will be used so that these wells may be measured and used in development of the water table map for this site. As a quality assurance check, MW-5 (one of the FFTF wells nearest to the investigation area) will be surveyed for comparison with established data. The FFTF investigation found odor but no visible hydrocarbons at MW-5. Elevation surveying will be conducted by a Rhode Island licensed surveyor, subcontracted by HALLIBURTON NUS.

Table 3-1 provides a summary of th number and type of sampl s to be collected in each area, and the analys s to b conducted on ach sampl . Table 3-2 lists the sample container, preservation and holding time requirements for each type of sample.

3.3.3 Abandoned Fuel Oil Pipeline Between Building 86 and Structure 143 Activities

Figure 3-1 indicates the approximate locations for the small diameter wells to be installed along the path of the abandoned fuel oil pipeline linking Building 86 and Structure 143. The indicated locations may be adjusted in the field as a result of actual site conditions.

Small Diameter Well Installation

Up to six small diameter wells will be installed in the backfill materials along the trench containing the abandoned fuel oil pipeline. Well completion depths will average between four (4) and six (6) feet below ground surface. These sampling points will determine whether hydrocarbons are present within the trench backfill materials. Sampling points which encounter free liquids (hydrocarbon and/or water) will b completed as permanent installations.

Well Development

The small-diameter wells will be developed immediately after installation. The purpose of well development is to remove silt and other fines which settle in the vicinity of the well screen and at the bottom of the well during installation. Well development will be accomplished by purging the well of silty water using a peristaltic or inertia pump. Development will continue until the purge water is as silt-free as possible and all fines have been removed from the bottom of the well. Purge water which contains no visible hydrocarbons will be discharged to the ground surface in the vicinity of the well. Purge water which contains visible hydrocarbons will be collected by the field team and transported to a bulk container located at the staging area elsewhere on-site.

Groundwater Sample Analysis

One groundwater sample will be obtained from each of the permanent small diameter wells (assumed to be 6) and submitted for laboratory analysis for TPH (by GC/FID method). Additional QA/QC samples will be collected at the frequency specified in Section 4.7.

If sufficient free product is present in any well (conventional or small-diameter), a product sample will b obtained instead of a groundwater sample and will be analyzed for TPH by GC/FID method only.

Elevation Survey

The location and elevation of the small-diameter wells will be surveyed to allow for accurate monitoring of water level measurements and construction of a water table contour map.

TABLE 3-1

SAMPLING AND ANALYSIS SUMMARY
UST REMEDIAL INVESTIGATION
COASTER'S HARBOR ISLAND

Location	Activity	Sample Type	No. of Samples	Analyses
CHI-074	Manhole Inspection	Sediment/water	10	TPH(1)
	Sump at Structure 114	Water	1	TPH(1)
	Conv. Monitoring Wells	Water	11	TPH(1), TCL VOC, TCL SVOC, RCRA 8 Metals
	Small Diameter Wells	Water	10	TPH(1)
CHI-143/Taylor Dr.	Manhole Inspection	Sediment/water	10	TPH(1)
	Soil Borings	Soil	6	TPH(1)
	Conv. Monitoring Wells	Water	4	TPH(1), TCL VOC, TCL SVOC, RCRA 8 Metals
	Small Diameter Wells	Water	5	TPH(1)
CHI-086/143 Abandoned Fuel Oil Line	Small Diameter Wells	Water	6	TPH(1)
QA/QC (level C QC)	Duplicates			
	- Sediment/Water (Manholes)		2	TPH(1)
	- Soil		1	TPH(1)
	- Water (Small Diameter Wells)		2	TPH(1)
	- Water (Conventional Monitoring Wells)		2	TPH(1), TCL VOC, TCL SVOC, RCRA 8 Metals
	Field Blanks			
	(1/source)		2	TPH(1), TCL VOC, TCL SVOC, RCRA 8 Metals
	Equip Blanks			
	(1/day, analyze every other one)			
	- during sed/water sampling (manholes)		2	TPH(1)
	- during soil sampling		1	TPH(1)
	- during water sampling		2	TPH(1), TCL VOC, TCL SVOC, RCRA 8 Metals
	Trip Blanks			
	(1/day during sampling of conventional wells)		2	TCL VOC

(1)EPA Method GC/SW846/8000 GC/FID HC Fingerprint

TABLE 3-2

SAMPLE CONTAINER, PRESERVATION AND HOLDING TIME REQUIREMENTS
UST REMEDIAL INVESTIGATION
COASTER'S HARBOR ISLAND

Parameter	Container	Preservation	Holding Time*	
			Soil	Water
TPH (Section 4.7 GC/FID)	Water: 2 1-liter amber glass, with teflon-lined lid Soil: 1 500-ml amber glass, with teflon lined lid	Cool, 4°C	Extract within 14 days, analyze 40 days	Extract within 7 days, analyze 40 days
VOCs	Water: 240-ml VOA vials with teflon lined lid	HCl to pH<2, Cool, 4°C		14 days
SVOCs	Water: 2 1-liter amber glass, with teflon lined lid	Cool, 4°C		Extract within 7 days, analyze 40 days
RCRA 8 Metals	Water: 1 1-liter plastic with teflon lined lid	HNO_3 to pH pH<2, Cool, 4°C		Metals: extract within 6 months Mercury: extract within 28 days

*Holding Time begins from date of sample collection, as per NEESA Requirements.

Water Level and Product Thickness Measurem nts

Water level and product thickness measurem nts will be made in the small-diameter wells approximately 5 w eks after well sampling is complete. The data will be used to develop water table elevation contour maps and to delineate the extent of free product found.

3.4 SAMPLE DESIGNATION SYSTEM

Field samples collected from the investigation area will each be assigned a unique field sample designation. The sample designation, or number, will consist of a soil boring or well designation code that identifi s the specific sampling location, a matrix type, sample depth and a quality control (QC) identifier. Any other pertinent information regarding sample identification will be recorded in the field logbooks and on sample log sheets. Table 3-3 provides a format for the sample designation system for this project.

3.5 SAMPLING EQUIPMENT AND PROCEDURES

A description of the field equipment and procedures follows.

3.5.1 Mobilization/Demobilization

Th Field Team will commence mobilization upon written or verbal notification from the Navy that field insp ction activities are scheduled to proceed and permission is granted to mobilize operations at th site. The PM will contact the appropriate Navy personnel at the Naval Facilities Engineering Command, Northern Division regarding the initiation of field investigations. Following the Navy notification, the PM will notify the FTL of the authorization, and the FTL will notify the Field Team members who are to participate in the field investigations. The FTL will be responsible for arranging for all necessary field equipment (listed in Appendix E), transportation, subcontractors, etc., and for coordinating the onsite activities with the POC. This will include preparation of subcontractor bid specs and conducting a subcontractor prebid site walk.

3.5.2 Field Sampling

Field sampling will include the collection of soil/ground water and QA/QC samples during the various drilling and sampling activities from the areas identified in Section 3.3. General field sampling procedures ar described in the HALLIBURTON NUS SOPs appended to this Work Plan (Appendix C). The following sections detail the site-specific sampling procedures for each matrix to be sampled. All sampling data will be recorded on sample specific data sheets and in the site logbook kept by the FTL or his/her designated substitute. All other events and sampling conditions will also be recorded in the site logbook.

3.5.2.1 Subsurface Soil Sampling Procedure

Soil sampling will be conducted in accordance with SOP GH-1.3, "Soil and Rock Sampling." Subsurface soil samples will be collected with a split spoon sampler. Sampling equipment will be decontaminated in b tween each sample. The samples will be screened with a photoionization detector (PID) for the presence of VOC and the responses will be recorded in the field logbook. The sample will be placed directly into

TABLE 3-3

SAMPLE DESIGNATION SYSTEM
UST REMEDIAL INVESTIGATION
COASTER'S HARBOR ISLAND

Location (Prefix)	Activity (second digit)	Sample Location* (third and fourth digit)	Depth Identifier (fifth digit)	QC Identifier (sixth digit)
A = CHI-074 B = CHI-Taylor Drive C = CHI - Abandoned Fu l Oil Line	Soil Boring = "B" Mon. Wells = "W" Sm. Dia. Wells = "D" Sumps = "SU"	01, 02, 03...	A, B, C	Field Sample = A Field Duplicate = B Field Blank = C Rinsate Blank = D Trip Blank = E

*Sample locations will be labeled sequentiallly and identified in field log book and on Chain-of-Custody.

Example field ID:

"AB02AA" = Soil Boring field sample from CHI-074 location 2 at upper level.
"BD03B" = Field Duplicate sample from small diameter well at CHI-143 location 3.

the appropriat contain r as outlined on Table 3-2 and in S ction 4.0. All observations regarding sample selection will be recorded in the site logbook.

3.5.2.2 Ground Water Sampling

Ground water sampling from installed monitoring wells and small diameter wells will be conducted in accordance with SOP SA-1.1, "Groundwater Sample Acquisition". Dedicated disposable sampling equipment such as polyethylene bailers will be used for sampling of monitoring wells. Due to their smaller internal diameter, small diameter wells will require sampling using a peristaltic pump and disposable tubing. Reusable equipment such as water level tapes will require proper decontamination. Expended sampling materials will be properly contained for disposal by the Navy.

Specific requirements for containment and disposal of well purge water have been defined prior to start of this program. Sampling points which show no evidence of free product will have their fluids discharged to the ground surface. Sampling points which indicate free product will have their fluids contained in a bulk container for later characterization and off-site disposal at a licensed facility by a licensed waste hauler. The HALLIBURTON NUS Team will be responsible for containment of the well purge water and will handle the disposal subcontract.

3.5.2.3 Decontamination Procedures

The following decontamination procedures comply with RIDEM and HALLIBURTON NUS Team SOP requirements. All nondisposable sampling and testing equipment which comes in contact with the sample medium will be decontaminated to prevent cross contamination between sampling points.

For the use of nondedicated sampling equipment which comes in direct contact with the sample, such as soil collection spatulas and trowels, the following decontamination sequence will be followed:

(1) Potable water and non-phosphate detergent (Alconox or Liquinox) wash (scrub equipment with brush).
(2) Potable water rinse.
(3) Distilled/deionized water rinse.
(4) Methanol (pesticide grade) rinse.
(5) Distilled/deionized water rinse.
(6) Total air dry.

Disposable sampling equipment will be used whenever possible. It will be requested that the subcontractor's sampling equipment be cleaned prior to arrival on site, and this will be confirmed with the subcontractor prior to the initiation of work.

3.5.3 Fi ld Cust dy Pr cedur s f r Samples

The FTL is responsible for the care and custody of the samples collected until they are either delivered to the analyzing laboratory or are entrusted to a carrier for shipment to the laboratory.

Sample logs and other field records shall always be signed and dated.

Chain-of-Custody (COC) sample forms shall be completed to the fullest extent possible prior to sample shipment. The forms shall include the following minimum information:

- Project Name
- Sample Number
- Source of the sample
- Location of the sample collection point
- Description of the sample location
- Matrix of the sample
- Type of sample (grab, composite, etc.)
- Preservation applied (or "None" if no preservation)
- Name of the person collecting the sample
- The analyses requested for each sample

The COC form shall be completed legibly using waterproof ink and shall be signed by the sampler. Similar information will be provided on the sample label which will be securely attached the sample bottle. The label will also include a description of the analyses to be conducted on the sample.

3.5.4 Transfer of Custody and Shipment Procedures

When shipped, samples shall always be accompanied by a COC record. When samples are transferred between individuals prior to placement of shipping container seals, the relinquishing and receiving individuals will both sign and date the form and note the time of custody transfer on the COC record. That record documents the sample custody transfer from field personnel to the laboratory, often via a common carri r. Upon arrival at the laboratory, internal sample custody procedures shall be followed.

Prior to shipment, the method of shipment, the courier's name, and any other pertinent information shall be entered into the remarks section of the COC record. The original of the record shall be sealed inside the shipping container to accompany the shipment; a copy of the record shall be retained by field personnel.

3.5.5 Sample Shipping Procedures

Samples shall be shipped in containers that meet all applicable state and Federal standards for safe shipment. Samples requiring refrigeration will be promptly chilled with ice or Blue Ice to a temperature of 4°C and will be packaged in an insulated cooler for shipment. Ice will be sealed in containers to prevent leakage of water. Samples will not be frozen.

The field COC documentation will be placed inside the shipping container in a s aled plastic envelope. The shipping container will then b sealed with nylon strapping tape or equivalent, and custody seals will be signed, dated and affixed to the container in a manner that will allow the r ceiver to quickly identify any signs of tampering that may occur during transport.

Shipment will be made by overnight courier within 24 hours of sample collection.

3.6 SAMPLE HANDLING AND ANALYSIS

Sample handling issues were discussed in Section 3.5. The field samples that are to be collected under this Work Plan were discussed in Section 3.3, and the planned analyses for those samples are indicated in Table 3-1. Sample container, preservation and holding time requirements are shown in Table 3-2.

3.7 WASTE HANDLING

It is anticipated that waste materials will be generated during the field investigation. These materials include:

- Drill cuttings
- Decontamination fluids
- Used Personal Protective Equipment (PPE)
- Used sampling equipment
- Well purge water

These wastes will be handled in the following manner:

- Drill cuttings will require collection and disposal at each boring location. Soils that are visibly clean may be disposed of in or around the boring hole as general fill. Soils which are visibly contaminated with hydrocarbons will be stockpiled in a designated area to be determined by the Activity. The soil will be placed on top of a poly liner and overlain by more poly so as to prevent dispersion of the soil by wind or water. After the analytical data from the soil boring/sampling program has been received and evaluated, a determination will be made as to the proper disposal method for the stockpiled soil. If off-site disposal is required, the HALLIBURTON NUS Team will arrange with a licensed waste hauler for additional sampling of the soil (if required), transportation and disposal at a licensed disposal facility.

- Phosphate-free detergent wash water, rinse water, and dilute nitric acid decontamination fluids will be allowed to fall on the ground within the decontamination area. Methanol is generally used in minor amounts and becomes diluted within other wash water generated during equipment decontamination This too may be discharged to the ground, or if preferred, may be contained in plastic carboys and transferred to the bulk container used to store well purge water.

- Because of the visual proximity to the Naval War College, used PPE will be bagged and sealed prior to disposal as general refuse. If PPE becomes grossly contaminated with hydrocarbons, it will be segregated from other PPE and disposed of as contaminated material. Contaminated mat rial will be drumm d and disposed of off-site by a licensed waste hauler under subcontract to the halliburton NUS Team at an approved facility. Drums will be moved by the subcontractor to the d signated storag ar a on a daily basis.

- Used sampling equipment, if generally free of hydrocarbons will be disposed of with the PPE as general refuse. Contaminated disposable equipment will require segregation from other equipment and proper disposal.

Well purge water which is visibly free of hydrocarbons will be discharged to the ground in the vicinity of the well. Well purge water containing visible hydrocarbons will be collected and transported to a bulk container on-site. After the analytical data from the groundwater sampling program has been received and evaluated, a determination will be made as to the proper disposal method for the containerized water. If off-site disposal is required, the HALLIBURTON NUS Team will arrange with a licensed waste hauler for additional sampling of the water (if required), transportation and disposal at a licensed disposal facility.

The HALLIBURTON NUS Team will be responsible for removal and proper disposal of all accumulated waste materials following completion of the field investigation program. Disposal will be arranged with licensed waste haulers at approved disposal facilities.

4.0 QUALITY ASSURANCE/QUALITY CONTROL PLAN

This QA/QC Plan describes the policies, organization, goals, functional activities (sample collection, chemical analyses, etc.), and generally accepted QA/QC protocols (referenced in Table 4-1) requir d to achieve the data quality objectives (DQOs) for the attached UST Remedial Investigation - Work Plan for Coaster's Harbor Island in Newport, RI (CTO # 0046).

4.1 PROJECT DESCRIPTION

A description of the project activities for this investigation is provided in Section 3.0 of this Work Plan

4.2 PROJECT ORGANIZATION AND RESPONSIBILITY

The project organization and personnel responsibilities are outlined in Section 2.0 of this Work Plan.

4.3 QUALITY ASSURANCE OBJECTIVES

Achieving the intended project objectives requires that data collected from the field conform to an appropriate level of quality. The quality of a data set is measured by certain characteristics of the data, namely: precision, accuracy, representativeness, completeness, and comparability (PARCC). Some of th parameters are expressed quantitatively, while others are expressed qualitatively. The PARCC goals for a particular project are determined by the intended use of the data, usually referred to as DQOs. DQOs are discussed in Section 4.3.1 and the PARCC parameters are discussed in Section 4.3.2. All laboratory analyses will be performed by a laboratory that has been approved by the Naval Energy and Environmental Support Activity (NEESA) and Northern Division.

4.3.1 Data Quality Objectives (DQO)

The analytical data generated as a result of the field investigations discussed in this document will be required to meet data quality level "C", as defined by NEESA in "Sampling and Chemical Quality Assurance Requirements for the Navy Installation Restoration Program" (NEESA 20.2-047B 6/88). Table 4-1 summarizes the analytical methods for this project.

4.3.2 PARCC Parameters

The PARCC goals for the work covered by this Work Plan are discussed in the following sections. The information obtained in reviewing the PARCC parameters will be incorporated into the UST RI report.

TABLE 4-1

SUMMARY OF ANALYTICAL METHODS AND DATA QUALITY OBJECTIVES[1]
UST REMEDIAL INVESTIGATION
COASTER'S HARBOR ISLAND

Analysis	Method
TPH - GC/FID	SW846/8000
TCL VOCs	SW846/8240
TCL SVOCs	SW846/8270
RCRA 8 Metals	SW846/6000 & 7000 Series

[1]Data quality objectives for this RI will be level "C", as defined by NEESA 20.2-047B.
[2]Test Methods for Evaluating Solid Waste, USEPA, SW846, Third Edition, November, 1986.

4.3.2.1 Pr cisi n and Accuracy

Field and laboratory precision and accuracy performance can aff ct the attainment of project objectives, particularly when compliance with established criteria is based on laboratory analysis of environmental samples.

Analytical precision and accuracy will be evaluated upon receipt of the laboratory data. Analytical precision will be measured as the relative standard deviation of the data from the laboratory (internal) duplicates. Analytical accuracy measures the bias as the percent recovery from matrix spike and matrix spike duplicate samples. EPA SW846 method recommended criteria and action limits will be applied to all Organic analyses.

Field sampling precision and accuracy are not easily measured. Field contamination, sample preservation, and sample handling will affect precision and accuracy. By following the appropriate SOPs, precision and accuracy errors associated with field activities can be minimized. Field duplicates and blanks (trip, field, and rinsate) will be used to estimate field sampling precision and accuracy. Field QC samples collect d during this investigation program will be sampled and analyzed in accordance with "Sampling and Chemical Quality Assurance Requirements for the Navy Installation Restoration Program" (NEESA 20.2-047B 6/88).

Validity of data with respect to its intended use will be assessed based on laboratory-supplied QA/QC data and protocols routinely employed for validation of analytical results. In general, results that are rejected by the validation process will be disqualified from application to the intended use. Qualified data will be used to the greatest extent practicable.

4.3.2.2 Representativeness

Representativeness describes the degree to which analytical data accurately and precisely define the population being measured. Several elements of the sampling and sample handling process must be controlled to maximize the representativeness of the analytical data (e.g., appropriate number of samples collected, physical state of the samples, site specific factors, sampling equipment, containers, sample preservation and storage, holding times, sample identity, and COC). The sampling program is designed to provide analytical data that are representative of the contaminant levels existing on the site.

Representativeness of data is also affected by sampling techniques. Sampling techniques are describ d in the SOPs (Appendix C) and in Section 3.0.

4.3.2.3 Completeness

Completeness describes the amount of data generated that meets the objectives for precision, accuracy, and representativeness versus the amount of data expected to be obtained. For relatively clean, homogeneous matrices, 100 percent completeness is expected. However, as matrix complexity and heterogeneity increase, completeness may decrease. Where analysis is precluded or where DQOs are compromised, effects on the overall investigation must be considered. Whether or not any particular sample is critical to the investigation will be evaluated in terms of the sample location, the paramet r in question, the intended data use, and the risk associated with the error.

Critical data points may not be evaluated until all the analytical results are evaluated. If, in the valuation of laboratory results, it becom s appar nt that the data for a specific medium ar of limited quality either with respect to the number of samples or to an individual analysis, a subsequent sampling event may be necessary.

For the purposes of this effort, 90 percent is established as the minimum acceptable level of completeness. A data point shall be determined to contribute to the completeness of the data set if the information provided is meaningful, useful, and contributes to the project objectives.

4.3.2.4 Comparability

One of the objectives of the field sampling effort is to provide analytical data that are characterized by a level of quality that is comparable between sampling points as well as with data collected during subsequent sampling efforts. By specifying the use of standard analytical procedures (EPA SW846 methods) and standard field sampling procedures (SOPs), the potential for variables to affect the final data quality have been effectively minimized. Analytical methods for the Work Plan are outlined in Tabl 4-1.

4.3.3 Quality Control Samples

Th QC samples to be collected during the sampling effort are identified below. QC samples includ field duplicates or replicates, laboratory duplicates or replicates, equipment rinsate blanks, and field blanks. Each type of field quality control sample will undergo the same preservation, holding times, analysis, reporting, and validation as the field samples. Field QC samples will be collected in accordanc with "Sampling and Chemical Quality Assurance Requirements for the Navy Installation Restoration Program" (NEESA 20.2-047B 6/88). Table 4-2 presents a summary of QA/QC samples to be collected for the UST RI at CHI, Newport.

4.3.3.1 Field Duplicates

Field duplicate results are used to assess the combined field and laboratory precision. The results are anticipated to exhibit more variability than laboratory duplicates, which measure only laboratory precision. The field duplicate sample should be clearly designated on the COC form. Field duplicates include replicate and collocated samples. Replicates are collected by mixing a double portion of the required volume of sample and dividing it into two sample containers. Collocated samples are two discrete samples obtained at the same sample point. Field duplicate samples will be collected at a frequency of 10% per sample matrix. Field duplicate results will be compared to assess sample homogeneity, handling, shipping, storage, preparation, and analysis.

4.3.3.2 Equipment Rinsate Blanks

Equipment rinsate blanks are obtained under representative field conditions by running analyte-fre deionized water through sample collection equipment after decontamination and prior to use, and placing it in the appropriate sample containers for analysis. These samples are used to assess the effectiveness of decontamination procedures. Rinsate blanks will be prepared at the rate of one per day during all sampling events. Rinsate blanks from every other day will be analyzed for the same parameters as the

TABLE 4-2

SAMPLE SUMMARY - ANALYTICAL PROGRAM
UST REMEDIAL INVESTIGATION
CHI, NEWPORT, RI

Parameter	Method	Sample Type	# Samples[1]	Field Dups 10%	Trip Blanks (1/cooler) VOCs only	Field Blanks (1/H_2O Source)	Rinsate Blanks (1/day) Analyze alternate days	Total Samples
VOCs	SW846/8270	Water Aqueous QC	15	2	 2	 2	 2	17 6
SVOCs	SW846/8270	Water Aqueous QC	15	2		 2	 2	17 4
RCRA 8 Metals	SW846/6000 & 7000	Water Aqueous QC	15	2		 2	 2	17 4
TPH	SW846/8000 GC/FID	Soil Sediment/Water Aqueous QC	6 63	1 6		 2	 5	7 69 7

SVOC = Volatile Organic Compounds
VOC = Volatile Organic Compound
TPN = Total Petroleum Hydrocarbons
[1]The number of samples presented in this table represent the maximum number of samples to be analyzed.

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related samples. COC for alternate rinsate samples will be marked "Hold do not analyz ". For this UST RI, soils will be sampled using a split spoon sampler and ground wat rs will be sampled using dedicated disposable sampling equipment. Rinsate b!:-nks are not required if dedicated or disposable field sampling equipment is used during sample coll ctio·

4.3.3.3 Field Blanks

Field blanks will consist of the source waters used in decontamination and steam cleaning. Field blanks will be prepared at the rate of one per source of water per sampling event and will be analyzed for the same parameters as the related samples. It is anticipated that there will be two (2) field blank samples: 1) potable water used for steam cleaning and 2) the ASTM Type II water used for decontamination.

4.3.3.4 Trip Blanks

Trip blanks will be used to assess the potential for contamination of samples due to contaminant migration during sample shipment and storage. Trip blanks will be prepared by filling sets of 40-ml VOA vials with laboratory deionized water, sealing the vials with septum-lined caps (allowing no headspace), and shipping at least one set of two vials from the laboratory with every sampling kit. The vials will remain in the shipping container from the time the sampling kit leaves the laboratory until it is received back from the field. Trip blanks will be required at a frequency of one set per cooler in which VOC samples are shipped.

4.4 SAMPLING PROCEDURES

Field sampling will be conducted in accordance with Sections 3.0 of this Work Plan and applicable SOPs (Appendix C). Allowable sample holding times, preservation, and sample container requirements are outlined in Table 4-3.

4.5 SAMPLE CUSTODY

Successful analysis depends on the capability to produce valid data and to demonstrate such validity. In addition to proper sample collection and handling, appropriate sample identification and COC procedures ar necessary to help support the validity of the data.

Sampling kits will be supplied by the laboratory. The sampling kits will be packaged in coolers and will include the appropriate sample containers, preservatives, COC records and trip blanks. Decontamination solvents and deionized water should also be obtained from the laboratory. Table 4-3 summarizes sample volumes,container types, preservation requirements, and holding times.

4.5.1 Sample Identification

As samples are collected and containerized in the field, the following information will be recorded on each label:

- Project identification
- Sampling location

TABLE 4-3

SAMPLE CONTAINER, PRESERVATION AND HOLDING TIME REQUIREMENTS
UST REMEDIAL INVESTIGATION
COASTER'S HARBOR ISLAND

Parameter	Container	Preservation	Holding Time*	
			Soil	Water
TPH (Section 4.7 GC/FID)	Water: 2 1-liter amber glass, with teflon-lined lid Soil: 1 500-ml amber glass, with teflon lined lid	Cool, 4°C	Extract within 14 days, analyze 40 days	Extract within 7 days, analyze 40 days
VOCs	Water: 240-ml VOA vials with teflon lined lid	HCl to pH<2, Cool, 4°C		14 days
SVOCs	Water: 2 1-liter amber glass, with teflon lined lid	Cool, 4°C		Extract within 7 days, analyze 40 days
RCRA 8 Metals	Water: 1 1-liter plastic with teflon lined lid	HNO_3 to pH pH<2, Cool, 4°C		Metals: extract within 6 months Mercury: extract within 28 days

*Holding Time begins from date of sample collection, as per NEESA Requirements.

- Sampl numb r
- Data and time of sample collection
- Parameters to be analyzed
- Initials of the sample collector

Each sample will be identified by a unique alphanumeric code (see Table 3-3). All information necessary to identity each sample, and the corresponding sample code, will be recorded in the field notebook Sampling locations will be recorded on a scale map of the site.

After collection, preservation, and labeling, the sample will be maintained under the COC procedures discussed below.

4.5.2 Chain-of-Custody Procedures

COC procedures are intended to maintain and permanently document sample possession from the time of collection to disposal, in accordance with federal guidelines. A sample is considered to be under a person's custody if:

- It is in that person's possession.
- It is in that person's view, after being in that person's possession.
- It was in that person's possession and was locked up by them to prevent tampering.
- It has been placed in a designated secure area by that person.

The COC record will be initiated in the field for all samples collected. At a minimum, the following information shall be recorded on the form:

- Signature of custodian
- Date of signature
- Sampling site identification
- Sampling date and time
- Sample identification
- Preservation, if any
- Sample description (type and quantity)
- Analyses to be performed
- COC tape number
- Method of shipment and courier name(s) in the remarks box, if applicable

The initial custodian will: sign the COC record; enter the date, time, and COC seal numbers; tear off and file the back copy with the appropriate sampling log; and place the remainder in the shipping container with the samples. The sample documentation will be placed in a sealed plastic bag and taped to the insid lid of the cooler. Each kit will be sealed with COC tape, which is signed and dated by the sample custodian.

All custodians will sign and date the COC form when they assume custody of the sample cooler, and again when they have relinquished custody to someone else. The shipper's waybill or airbill will be retained by the last custodian prior to shipment.

The laboratory sample custodian will receive and sign the form for the laboratory, and record the date, time. and COC tape numb rs. The laboratory log-in record will explicitly state the condition of the COC seal, any evidence of damage, whether the seal is air-tight, and the compl ten ss of accompanying records. After inspection, each sample will be logged in and assigned a unique laboratory sample identification numb r. In addition, the following information will be entered in the logging system for each sample:

- Field sample identification number
- Laboratory sample identification number
- Date received
- Project name and number
- Collection date
- Sample type
- Condition of sample
- Sample pH
- Temperature of sample cooler (if samples were stored on ice)
- Analyses to be performed
- Assigned storage location

The laboratory sample custodian will notify the laboratory project director if samples are received that are damaged, warm, frozen, or incompletely documented. The laboratory project director will contact th lab program coordinator who will decide on the disposition of these samples.

After sample log-in is complete, a copy of the COC record, with laboratory sample numbers and notations of any discrepancies, will be sent to the PM to be entered into the project file. The original COC form will be filed in the laboratory with the shipper's waybill or airbill attached.

4.6 CALIBRATION PROCEDURES

4.6.1 Field Instrumentation

Field equipment normally requiring calibration will be calibrated and operated in accordance with the manufacturer's instructions and manuals, and the appropriate SOP's. At a minimum, calibration will be performed at the start of field activities each day. Recalibration will take place as necessary during the course of each day. The calibration results for each field instrument will be recorded in the field log book or on appropriate field data sheets.

4.6.2 Laboratory Instrumentation

Calibration is required to ensure that the analytical system is operating correctly and functioning at th proper sensitivity to meet the necessary detection limits. For this project, all samples will be analyzed by GC/FID to characterize the presence or absence of petroleum hydrocarbons; specifically No. 6 or No. 4 fuel oils, as discussed in Section 3.1 - Site Background. Separate calibration standards should be prepared from reference standards of No. 6 fuel oil and No. 4 fuel oil. Calibration curves should be prepared at a minimum of three concentration levels. Estimated detection limits for these fuel oils would be 100 ug/L in aqueous samples and 5 ug/g in soils.

4.7 ANALYTICAL PROCEDURES

Environmental samples collected during the field investigations cover d by this Work Plan will be analyzed by a NEESA-approved laboratory under a Basic Ordering Agreement (BOA) with the HALLIBURTON NUS Team. All analytical procedures will conform to established methods approved by the EPA, as defined by "Sampling and Chemical Quality Assurance Requirements for the Navy Installation Restoration Program" (NEESA 20.2-047B 6/88) and meet NEESA quality level "C". Analytical methodologies to be used for this project are summarized in Table 4-1.

4.7.1 TPH Analyses

All samples collected during this field investigation will be analyzed and reported for total petroleum hydrocarbons (TPH) using GC/FID. Calibration procedures are summarized in Section 4.6.2. Samples will be extracted following SW 846 methodology for waters (3510 or 3520) and soils (3540 or 3550) and analyzed by GC/FID. If any "free product" or visibly contaminated soil and/or water sample are taken; EPA extraction Method 3580 (Waste Dilution) should be used prior to GC/FID analysis. All samples should be reported as TPH compared to the referenced standard, and identified or not identified as either No. 4 or No. 6 fuel oil. If No. 4 or No. 6 fuel oil are not identified in any sample, other hydrocarbons found to b present in the sample should be qualitatively identified, if possible. Specific analytical methodology shall be approved y the QA Manager prior to the onset of this field investigation and prior to the laboratory analysis.

4.8 DATA REDUCTION, VALIDATION, AND REPORTING

4.8.1 Laboratory Data Review

The process of reviewing analytical results and documentation against established criteria is a critical step. The Laboratory Quality Control Coordinator will be responsible for performing data review in the laboratory.

The precision and accuracy of data will be computed and compared to the control limits as part of the data revi w process. Precision is determined from the analytical results of duplicate samples. Accuracy is computed from spike recoveries.

4.8.2 Analytical Records

Reports of analyses will be delivered to the project manager within the time period requested at the time of sample delivery.

Analytical results will be reported in accordance with the referenced methodology (Table 4-1) and should include all deliverables as outlined in Section 4.8.3.

4.8.3 Data D liv rabl s

A report narrative should accompany each submission, summarizing the contents, results and all relevant circumstances of the work. The following data deliverables are required from the laboratory.

- Analyses requested.
- Sample Identification
  - Date and time collected
  - Date extracted
  - Date and time analyzed
  - Chain of Custody documentation; including sample log-in tracking information
- Sample Results
  - Sample results; including integration (raw) data, sample result summary sheets and chromatograms.
  - Field duplicate results.
  - Laboratory blanks, field blanks, equipment rinsate blank results.
  - Matrix spike/matrix spike duplicate and/or blank spike results.
  - Surrogate recoveries, if applicable.
- Supporting QA/QC
  - Methodology
  - Method detection limits
  - Initial and continuing calibration summaries; including standard chromatograms and integration tables
  - Percent solids for soils, sludges and sediments
  - Cleanup procedures used, if applicable
  - Laboratory QA/QC procedures and checklists

4.8.4 Data Validation

Data validation is a process of review of the analytical results and documentation against established criteria. Validation of all data generated as part of this field investigation will be performed in accordance with HALLIBURTON NUS, NORTHDIV and EPA guidelines. EPA guidelines are presented in the following documents:

- National Functional Guidelines for Organic Data Review, USEPA draft, December 1990, Revised June, 1991.
- Laboratory Data Validation Functional Guidelines for Evaluating Organic Analyses, USEPA; February 1, 1988, modified November 1, 1988.
- Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses, USEPA; June 13, 1988, modified February 1989.

Validation of data will involve thorough review of method specified QA/QC criteria, including method blanks, field blanks, instrument calibration, spikes and duplicates.

Validation will be performed by the HALLIBURTON NUS Team and will include a QA assessment to assess that the prop r analytical and QA/QC protocols were followed by the laboratory. Data qualifiers will be reviewed by the data validator and specific data validation qualifiers will be added to data spreadsheets.

A peer review of the data validation report will be conducted by a staff member whose qualifications are at least equivalent to those of the originator.

4.9 INTERNAL QUALITY CONTROL

QC samples will be collected in the field to assess sample contamination, precision, and accuracy. The types and frequency of QC samples that will be prepared during this field investigation are discussed in Section 4.3.3. A summary of the QC samples to be collected during the UST RI at CHI, Newport is presented in Table 4-2.

Internal laboratory QC checks include matrix spike and matrix spike duplicate analysis, method blank analysis, and system monitoring compounds (surrogate) recoveries. Laboratory QC procedures will be performed in accordance with EPA requirements and NEESA quality level "C".

4.9.1 Method Blanks

Method or preparation blanks are generated within the laboratory during the processing of the actual samples. These blanks are processed using the same reagents and procedures and at the same time as the actual samples which are being monitored. Contamination found in the preparation blank would indicate that similar contamination found in the samples may have been introduced in the laboratory and is not actually present in the original samples. Method blanks will be prepared and analyzed for VOCs at a frequency of one per analytical batch, or one per 12-hour analysis period, whichever is greater. Method blanks will be prepared and analyzed for all other samples at a frequency of one per 20 samples or one per day, whichever is greater.

4.9.2 Laboratory Duplicates

Duplicate samples prepared in the laboratory account for analytical variability only. Laboratory duplicates are prepared by thoroughly mixing and splitting duplicate samples and analyzing the resulting samples following the same procedures. The sample which is to be analyzed as a laboratory duplicate will be identified on the sample label and COC form.

For organic analyses, the laboratory duplicates are analyzed as field duplicates and matrix spike/matrix spike duplicates, as discussed in Section 4.3.3.1 and 4.9.3. Assessment of duplicate results will be consistent with EPA and NEESA guidelines.

For inorganic analyses, laboratory duplicates will be analyzed from each group of samples of a similar matrix type and concentration. Laboratory duplicate results will be assessed in accordance with EPA and NEESA guidelines.

4.9.3 Matrix Spik s and Matrix Spike Duplicates

Matrix spikes ar pr par d by adding a known quantity of analyte into an actual field sample. The matrix spike for this analysis will be prepared by adding a known quantity of either No. 4 fuel oil or No. 6 fuel oil to a field sample and preparing and processing the spiked sample in the same manner as the field samples. Since there are no method specified recoveries for this method; recoveries will be assess d using the professional judgement of the laboratory and the project QA/QC Manager.

Matrix spike results are expressed in terms of percent recoveries. The percent recovery is obtained by dividing the amount of spike recovered by the known amount spiked and multiplying the quotient by 100. In general, matrix spike percent recoveries (%R) should be expected to fall between 80 to 120%.

Matrix spike duplicates are identical to matrix spikes. Another aliquot of the same field sample used for the matrix spike is fortified with an identical quantity of analyte and processed in an identical manner. In addition to providing a measure of the accuracy of the determination, the results of the matrix spike and matrix spike duplicate provide a measure of the precision of the determinations. The precision is expressed as the relative percent difference (RPD) and is calculated by dividing the difference between determinations by th average value and multiplying the quotient by 100.

For organic analyses, samples for matrix spike/matrix spike duplicate analyses will be collected at a frequency of one per every ten samples. For all other analyses, samples for matrix spikes will be collected at a frequency of one per every twenty samples.

4.9.4 System Monitoring Compounds

System monitoring compounds (surrogates) are added to each sample, blank, matrix spike and matrix spike duplicate prior to analysis. The purpose of the system monitoring compounds (surrogates) is to evaluate the preparation and analysis of the samples.

A surrogate compound used for this analysis will be specific to the GC/FID methodology. Discussions with the laboratory prior to the onset of this project will determine the specific surrogates for this analysis. As with matrix spike recoveries; surrogate recoveries will be assessed using the professional judgement of the laboratory and the project QA/QC Manager.

4.10 SYSTEMS AND PERFORMANCE AUDITS

System audits will be performed to evaluate all components of the measurement system in order to assure that work is being implemented in accordance with the approved project plan and in an overall satisfactory mann r. Systems audits should include an evaluation of both field and laboratory QC procedur implementation. Systems audits are performed prior to or shortly after systems are operational; however, such audits should be performed on a regularly-scheduled basis during the project.

Performance audits are an assessment of project-specific monitoring activities in the field and in the laboratory. These audits should focus on actual QC activities of the data collection system and should include an evaluation of:

- Sample collection activities
- Sample analysis activities
- Equipm nt maintenance and calibration
- Decontamination protocols
- Sample containers, preservation techniques, and sample COC
- QC sample collection

Performance audits should be performed periodically throughout the project.

Audit reports will be documented by the QA Manager and included in the project files.

4.11 PREVENTIVE MAINTENANCE

Fi ld measurement equipment will be maintained in accordance with the SOPs and manufacturer's instructions. This field equipment maintenance program consists of the following elements:

- The equipment manager keeps an inventory of the equipment in terms of items, (model and serial number) quantity, and condition. Each item of equipment is signed out when in use, and its operating condition and cleanliness checked upon return.

- The equipment manager conducts routine checks on the status of equipment and is responsible for the stocking of spare parts and equipment readiness.

- The equipment manager maintains the equipment manual library and trains field personnel in the proper use and care of equipment.

- The FTL is responsible for working with the equipment manager to make sure that the equipment is tested, cleaned, charged, and calibrated in accordance with the manufacturer's instructions before being taken to the job site.

4.12 DATA ASSESSMENT PROCEDURES

The data validation procedures will be used by the Data Validator to assess duplicate, spike, and blank samples which have been submitted to the analytical laboratory from the field or generated internally by the laboratory in accordance with this QA/QC Plan. The purpose of implementing these procedures is to verify that the chemical data generated during the project are accurate, precise, and complete and are therefore representative of Site conditions. The format for QC data assessment and reporting is presented below.

4.12.1 Procedures for Assessing Data Accuracy, Precision, and Completeness

Chemical data generated from sample analyses will be assessed for accuracy, precision, and completeness for both the analytical laboratory and field sample collection programs. The goal of these programs is to provide data that is representative of the Site. To meet this goal, a combination of statistical procedures and qualitative evaluations will be used to check the quality of the data. Data will not be eliminated from the database based on the results of the statistical analyses. If problems arise and data are found to d viate from previous analyses or surrounding conditions, the data will be annotated. Sample re-collection and re-analysis may be used as a corrective action.

The QA/QC assessment program will evaluate Site data based on the types of control samples described in Section C.3.3 and C.9 (spikes, blanks, duplicates, etc. and summarized below).

4.12.1.1 Blanks

Blanks will be used to evaluate whether laboratory or field procedures represent a possible source of contamination of the field samples. Equipment rinsate blanks are QA/QC samples prepared in the field by passing analyte-free water through the field sampling device into empty sample containers and submitted to the laboratory for the appropriate analyses. Field blanks consist of the source water used in decontamination. Method blanks are laboratory blanks prepared and analyzed by the laboratory as part of the laboratory QA program.

Th procedure for assessing blank samples is as follows:

- Tabulate the blank sample data.
- Identify any blank samples which have detected compounds.
- If no compounds are detected in any blank samples, no qualifications are necessary to the data.
- If any compounds are found in blank samples, the compound(s) and concentration(s) will b evaluated and the field data for that sample delivery group assessed according to U.S. EPA data validation criteria. No data will be removed from the database on the basis of compounds being detected in blank samples. Appropriate qualifications, however, will be made to the data and will be summarized in the validation report.

4.12.1.2 Matrix Spike Samples

Spiked samples will be used to evaluate the analytical precision and accuracy of the laboratory. Matrix spik samples for inorganic analyses and matrix spike/matrix spike duplicate samples for organic analyses will b prepared by the laboratory on designated site samples according to the particular methodology specified in Table 4-1.

Matrix spikes and matrix spike duplicates (MS/MSDs) will be assessed on the basis of percent recovery (%R). The formula for calculation of %R is as follows:

$$\%R = \frac{SRR - SR}{SA} \times 100$$

SSR = Spiked Sampl Result (µg/Kg)
SR = Sampl R sult (µg/Kg)
SA = Spik Amount (µg/Kg)

MS/MSD recoveries must fall within the established control limits specified in the cited methods (Table 4-1).

4.12.1.3 Duplicate Samples

Duplicate samples will be used to evaluate the analytical precision of the laboratory. Field duplicate preparation and analysis is discussed in Section 4.3.3.1. Laboratory duplicates preparation and analysis is discussed in Section 4.9.2.

Duplicate samples will be compared on the basis of RPD. The formula for calculation of RPD is as follows:

$$\textbf{RPD} = \frac{\textbf{Sample A - Sample B}}{\textbf{Average of Sample A+B}} \times 100$$

Duplicate analyses must have a RPD less than the established control limits specified in the cited methods (Tabl 4-1).

4.12.1.4 Completeness

Completeness is the adequacy in quantity of valid measurements to ensure accurate interpretation and to meet the needs of the sampling and analysis program. Valid measurements will be determined through the examination of project documentation and through the outcome of the previous assessment criteria. Completeness will be addressed by ensuring that valid results are achieved, based upon all of the above criteria, for 90 percent of the samples analyzed. Overall completeness for the collected sample data will be calculated according to the following equation:

$$\textbf{\% Completeness} = \frac{\textbf{\# of Valid Results}}{\textbf{\# of Expected Results}} \times 100$$

Analytical data that fall outside the control limits will be qualitatively evaluated. This evaluation will focus on historic variations in concentration, whether problems arise for one particular compound or random compounds, and whether the problem is limited to one or several sampling locations or wells, etc. If data quality problems arise, the analytical data will be annotated in accordance with data validation guidelines and the laboratory will be notified for corrective action, as appropriate.

4.13 CORRECTIVE ACTION

The QA program will enable problems to be identified, controlled, and corrected. Potential problems may involve nonconformance with the SOPs and/or analytical procedures established for the project or other unforeseen difficulties. Any person identifying an unacceptable condition will notify the project manager. The PM, with the assistance of the project QA/QC officer, will be responsible for developing and initiating appropriate corrective action and verifying that the correction action has been effective. Corrective actions may includ resampling and/or reanalysis of samples or modifying proj ct procedures. If warrant d by the sev rity of th problem (for example, if a chang in the approved work plan is requır d), the Navy will be notified in writing and their approval will be obtained prior to implementing any change. Additional work that is dependent on a nonconforming activity will not be performed until the source of the problem has been addressed.

4.14 QUALITY ASSURANCE REPORTS/DOCUMENTS

A bound, weatherproof site logbook shall be maintained by the FTL. The FTL or his/her designee shall record all information related to sampling and field activities. The information should include sample description, location, sampler, sampling time, weather conditions, unusual events, field measurements, description of photographs, etc. Sample collection data will also be recorded on a matrix-specific sample coll ction data log for each collected sample. The site logbook will contain a summary of each day's activities and will reference field notebooks and sample collection data log sheets when applicable. The site logbook entries and format are described in the SOPs.

Custody of samples must be maintained and documented at all times. COC begins with the collection of the samples in the field. Section 4.5 addresses the topic of sample custody.

At th completion of field activities, the FTL shall submit to the PM all field records, data, field notebooks, the site logbook, COC receipts, sample collection data log sheets, and health and safety records and sheets. The PM shall ensure that these materials are properly labelled, organized, and entered into the project file.

Changes in project operating procedures may be necessary as a result of changed field conditions or unanticipated events. A summary of the sequence of events associated with field changes is as follows:

- The FTL notifies the PM of the need for the change.
- If necessary, the PM will discuss the change with the pertinent individuals (e.g., HALLIBURTON NUS managers and Navy personnel) and will provide a verbal approval or denial to the FTL for the proposed change.
- The FTL will document the change on a TMR and forward the form to the PM at the earliest convenient time (e.g., end of the work week).
- The PM will sign the form and distribute copies to the Program Manager, QA Manager, FTL, and the project file.
- A copy of the completed TMR form will also be attached to the field copy of the affected document (i.e., HASP).

APPENDIX A
LIST OF ABBREVIATIONS/ACRONYMS

APPENDIX A
LIST OF ABBREVIATIONS/ACRONYMS

ACGIH	American Conference of Governmental Hygienists
BOA	Basic Ordering Agreement
CAT	Chemical Additive Tank
CECOM-EMI	Communications Electronics Command-Electromagnetic Interference
CGI	combustible gas indicator
CHI	Coaster's Harbor Island
CHSM	CLEAN Health and Safety Manager
CHSO	Company Health and Safety Officer
COC	Chain-of-custody
CRZ	Contamination Reduction Zone
DQO	data quality objectives
FFTF	Fire Fighter Training Facility
FTL	Field Team Leader
FSP	Field Sampling Plan
GC/FID	Gas chromatograph/Fingerprint Identification
HASP	Health and Safety Plan
IR	Installation Restoration
ml	milliliter
NEESA	Naval Energy and Environmental Support Activity
NIST	National Institute of Standards and Technology
NORTHDIV	Navy Northern Division
NVLAP	National Voluntary Laboratory Accreditation Program
PARCC	precision, accuracy, representativeness, completeness, and comparability
PCB	polychlorinated biphenyls
PEL	Permissible Exposure Limit
PID	photoionization detector
PM	Project Manager
POC	Point of Contact
PPE	personal protective equipment
ppm	parts per million
PVC	polyvinyl chloride
QA/QC	Quality Assurance/Quality Assurance
RIDEM	Rhode Island Department of Environmental Management
RPD	relative percent difference
RPM	Remedial Project Manager

SI	Site Inspection
SMP	Site Management Plan
SOP	standard operating procedure
SSO	Site Safety Officer
SVOC	semi-volatile organic compounds
TAL	target analyte list
TCL	target compound list
TCLP	toxicity characteristic leaching procedure
TMR	Task Modification Request
TPH	Total Petroleum Hydrocarbons
UST	underground storage tank
UST RI	underground storage tank remedial investigation
VOC	volatile organic compounds

APPENDIX B
HEALTH AND SAFETY PLAN

Final
Health and Safety Plan
For
Field Sampling Program
at
Coaster's Harbor Island

Newport, Rhode Island

Prepared by: Kathy Harvey — Date: 5/10/94
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CLEAN Health and Safety Manager

Approved by: Larry Pannell — Date: 5/10/94
Larry Pannell
Project Manager

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1.0 INTRODUCTION

1.1 HASP REQUIREMENTS

This site-specific Health and Safety Plan (HASP) has been developed by the HALLIBURTON NUS Team to establish the health and safety procedures required to minimize any potential risk to personnel who will perform activities related to the proposed field sampling program at Coaster's Harbor Island located at the Naval Education and Training Center (NETC) in Newport Rhode Island. The provisions of this plan apply to all HALLIBURTON NUS Team personnel and HALLIBURTON NUS subcontractor personnel who will potentially be exposed to safety and/or health hazards related to activities described in Section 3.0 of this HASP.

This HASP has been written to comply with the requirements of the Occupational Safety and Health Administration (OSHA) Hazardous Waste Operations and Emergency Response Standard (29 CFR 1910.120), as well as guidance set forth in the CLEAN Health and Safety Management Plan (HSMP), developed by HALLIBURTON NUS (dated August 1991). All activities covered by this HASP must be conducted in complete compliance with this HASP and with all applicable federal, state and local health and safety regulations. Personnel covered by this HASP who cannot or will not comply will be excluded from site activities.

Subcontract personnel who choose to follow this plan must distribute a copy of this plan to each employee who will work at the site. Each employee must sign a copy of the attached health and safety plan sign-off sheet (see Attachment A). Subcontractors to the HALLIBURTON NUS Team may develop their own HASP related to their specific on-site activities. This HASP must minimally be as protective as the HALLIBURTON NUS Team's and must be submitted for the HALLIBURTON NUS Team's review at least two weeks prior to the start of on-site activities.

1.2 HASP MODIFICATIONS

Please note that this HASP only pertains to the proposed tasks, as listed in Section 3.0 of this document. A task-specific HASP will be developed at a later date for any other subsequent investigative/remedial activities at the site.

The procedures in this HASP have been developed based on current knowledge regarding the specific chemical and physical hazards which are currently known or anticipated for the operations which are to be conducted at this site. This information was developed as a result of a Site Reconnaissance performed by ENSR in April, 1992. Should additional information become available regarding site hazards or should planned field sampling operations at the site change, it may be necessary to modify this HASP. All proposed modifications to this HASP must be reviewed and approved by the HALLIBURTON NUS Team health and safety members and Project Manager (PM) before such modifications are implemented.

Any significant modifications must be incorporated into the written document as addenda and the HASP must be reissued. The HALLIBURTON NUS PM will ensure that all personnel covered by this HASP receive copies of all issued addenda. Sign-off forms will accompany each addendum and must be signed by all personnel covered by the addendum. Sign-off forms will be submitted to the HALLIBURTON NUS PM. The HASP addenda should be distributed during the daily safety meeting so that they can be reviewed and discussed. Attendance forms will be collected during the meeting to document the review of new information.

1.3 RESPONSIBILITIES

Responsibility for the implementation of health and safety at the Site is an integrated effort among the HALLIBURTON NUS Team Project Manager (PM), the CLEAN Health and Safety Manager (CHSM), the Company Health and Safety Officer (CHSO), the designated Site Safety Officer (SSO), the subcontractors and Field Team staff.

The CLEAN Health and Safety Manager (Matthew Soltis) and the Company Health and Safety Officer (William Trabilcy) are responsible for developing, interpreting and modifying, when necessary, the site specific Health and Safety Plan. When required, the CHSM and CHSO are responsible for auditing the project to verify compliance with the HASP.

The PM (Gail Scott) and SSO (to be appointed by the PM prior to beginning on-site activities) are responsible for implementing the requirements of the HASP. The PM is required to inform the CHSM and CHSO of project developments and maintain an open line of communication with each. The PM is responsible for distributing a copy of this HASP to the subcontractor and to all members of the HALLIBURTON NUS Field Team. The PM is responsible for collecting the training and medical documentation and the HASP sign-off sheets from the HALLIBURTON NUS Field Team and subcontractors (s e Section 9.0 of this document). The PM is responsible for forwarding these records to the CHSM.

The SSO is responsible for directing and implementing the HASP in the field and ensuring that all site personnel follow the requirements of the HASP. In consultation with the CHSM and CHSO, the SSO has the authority to correct all health and safety deficiencies and to immediately stop work in cases where imminent danger is perceived. The SSO is responsible for initiating emergency response and coordinating site vacuation when necessary. An alternate SSO will be named at the commencement of investigative activities. The alternate SSO will assume the responsibilities of the SSO in his/her absence.

2.0 SITE DESCRIPTION/HISTORY

2.1 FACILITY HISTORY & USE

Coaster's Harbor Island (CHI) is located at the Naval Education and Training Center (NETC), in Newport, Rhode Island (Figure 1). CHI is situated just off the coast of Newport within Narragansett Bay and is connected to the mainland via two bridges. The island encompasses an area of approximately 0.2 square miles with approximately 80 to 90 percent of the island occupied by structures and paved areas.

CHI was acquired by the Navy in 1881 from the City of Newport to serve as a training center. In 1884, the Naval War College was established on the island. A causeway and bridge linking the island to the mainland was constructed in 1892. Various episodes of expansion and structural development on CHI has occurred generally during buildup of activities related with World Wars I and II and subsequent expansions of the Naval War College during the 1950's and 1970's (Envirodyne Engineers, 1983). The Naval War College is currently still active on CHI and the island is still much in use.

2.2 FACILITY CONDITIONS

During a recent construction activity to upgrade the electrical distributing system on Coaster's Harbor Island, oil contaminated soil and groundwater were discovered in the vicinity of the old Fire Fighter Training Facility (FFTF). In addition, oil was found in a manhole located some distance from the FFTF (Structure 143 area). The FFTF is currently being investigated under the Installation Restoration Program (IRP). It is unknown whether the contamination found in the manhole is related to the FFTF, or to some other source.

Structure 74, an oil storage reservoir centrally located on CHI is considered to be a suspected or potential source of hydrocarbons released to the environment and observed at the manhole and other areas on site. Figure 2indicates the relative locations of Structure 74 and the subject manhole.

Structure 74, which consists of two (2) 282,000-gallon capacity fuel oil storage bunkers (in one structure), was constructed during 1917 as the fuel oil storage system for CHI. Structure 74 provides fuel to the CHI power plant (Structure 86) via subsurface trench and piping system. The structure is rectangular in shape having approximate dimensions of 145x55x11 feet with a common wall separating both storage vaults. The structure was constructed with reinforced concrete used in the floor slab, walls and ceiling. According to the plan specifications, four (4) inches of reinforced concrete is present in the floor slab, eight (8) inches of reinforced concrete present in the walls and ceiling. No information on original structural linings or coatings for the concrete surfaces were noted on the drawings.

Intermittent monitoring of oil and water levels in previously installed probes by NETC personnel between October, 1989 and January, 1990 indicated a reduction of oil in some probes but an increase in oil in others. In August of 1989, 4 monitoring wells were installed to the north and west of Structure 74. Three wells did not encounter ground water. One well, MW-2, indicated that free product might be present in the groundwater.

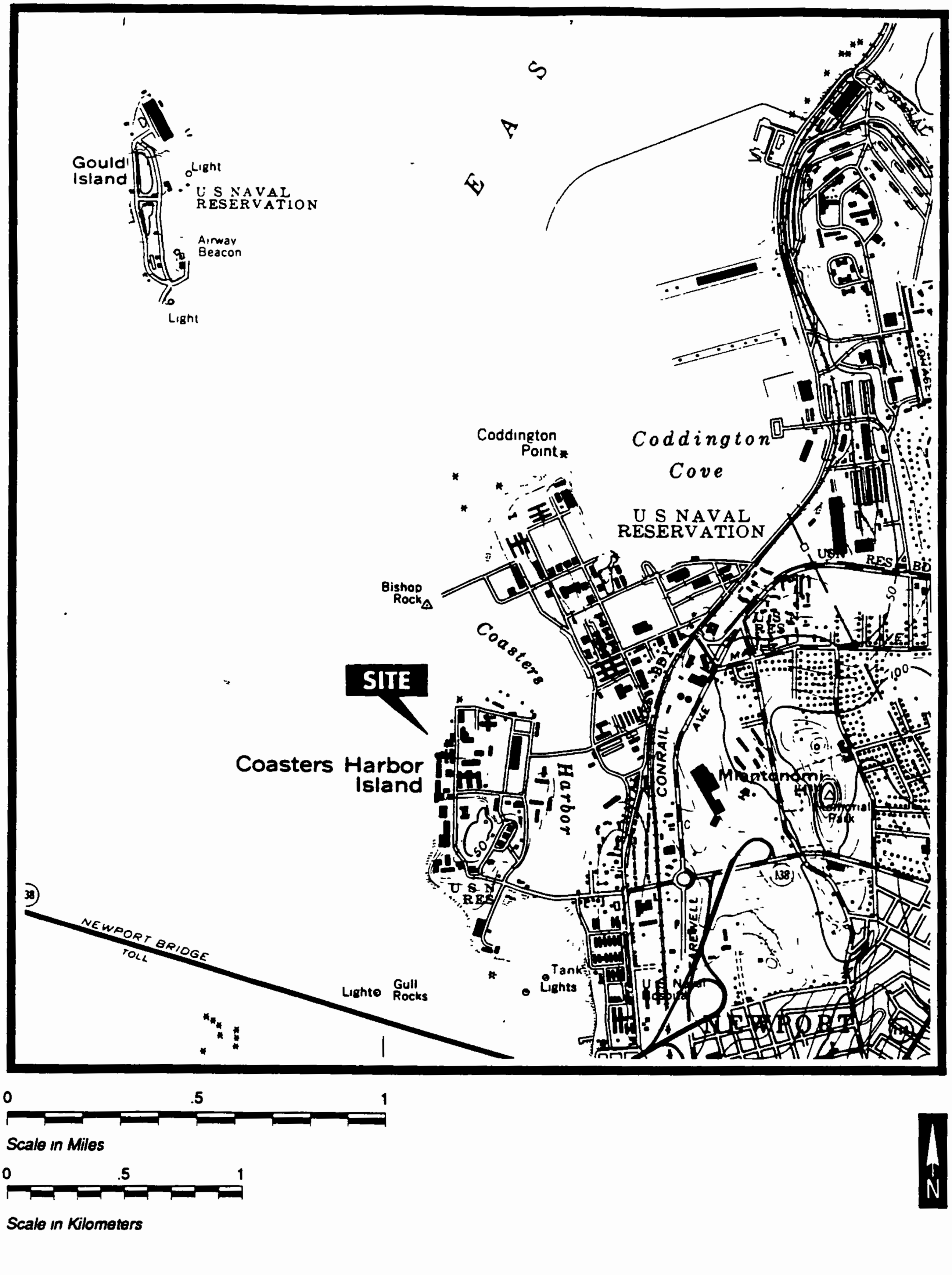

FIGURE 1
SITE LOCATION MAP - COASTERS HARBOR ISLAND

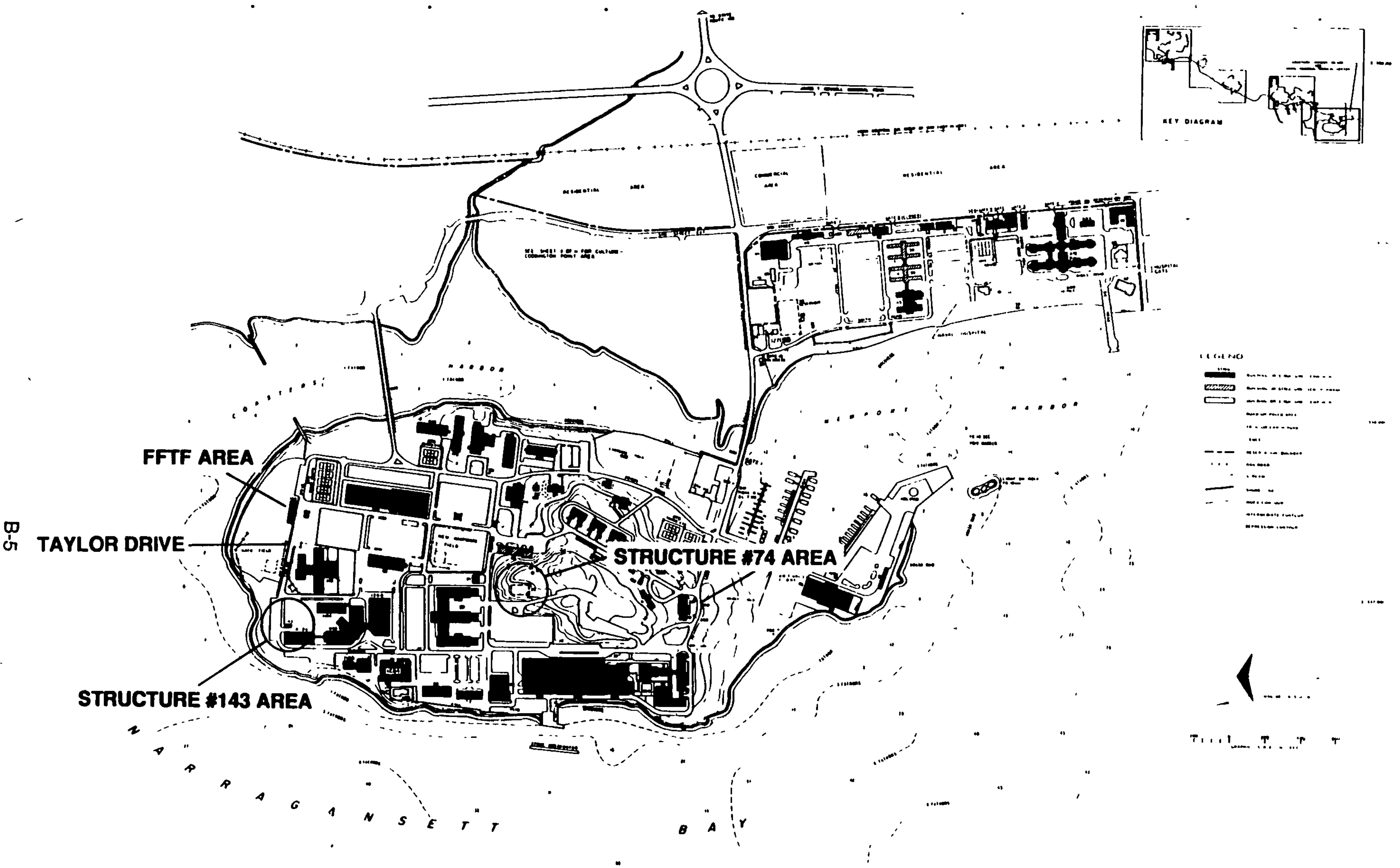

FIGURE 2
PROJECT LOCATION - COASTERS HARBOR ISLAND

3.0 SCOPE OF WORK

The objective of the proposed Field Program is to:

- Investigate potential sources of hydrocarbon contamination in two areas; Structure 74 and the electrical distribution system manholey near Structure 143.
- Investigate around Taylor Drive in the FFTA soils and groundwater.
- Evaluate remedial alternatives.

To meet these objectives, the following investigative tasks are proposed for each area.

- Manhole inspection in nearby utility trenches for hydrocarbon presence.
- Overburden soil borings and well installation for ground water monitoring and extent of contamination determination.
- Bedrock borings and well installation to determine bedrock fracture patterns and extent of contamination.
- Microwell installation within utility trench backfill to determine water levels or presence of hydrocarbons.
- Soil boring sample analysis to determine hydrocarbon concentrations.
- Ground water sampling and analysis to determine hydrocarbon concentrations.

No entry into, or sample collection from, manholes is planned. If such activities become part of the Field Program, the CHSO shall be contacted and the provisions of this HASP will be augmented.

4.0 HAZARD ASSESSMENT

The following chemical and physical hazard assessment applies only to the proposed activities covered by this HASP.

The following list of chemical contaminants of concern has been developed for the proposed activities. This is based on existing information relating to Structure 74 (oil storage reservoir). This HASP will be amended should additional information become available concerning the types of contamination present or suspected of being present at this site.

4.1 CHEMICAL HAZARDS

4.1.1 Fuel Oils

Previous observation and sampling indicate the potential for fuel oil contamination to be present at all proposed sampling locations.

Fuel oils are considered to be of moderate to low toxicity. Federal or recommended airborne exposure limits have not been established for the vapors of fuel oils. However, inhalation of low concentrations of the vapor of either may cause mucous membrane irritation. Inhalation of high concentrations of the vapors may cause extensive pulmonary edema. Chronic direct skin contact with the liquids may produce skin irritation.

B cause of the relatively low vapor pressure of fuel oils, overexposure to their vapors is not expected to occur in the outdoor environment. Dusts from soils that are contaminated with fuel oils may be generated during sub-surface activities or sample collection. Dermal contact is the most likely route of exposure.

4.1.2 Other Chemicals

Material safety data sheets (MSDSs) for the decontamination solutions that the HALLIBURTON NUS Team will use during the investigations are provided in Attachment B of this document. It is the SSO's responsibility to ensure that all containers of decontamination solutions are labeled in accordance with OSHA's Hazard Communication Standard. The likely route of exposure to these solutions is through direct dermal contact, although a splash hazard is also possible. To reduce the potential for contact with the d contamination solutions, personal protective equipment, as described in Section 6.1 of this HASP, will be worn.

4.2 PHYSICAL HAZARDS

4.2.1 Heat Stress

Sweating does not cool the body unless moisture is removed from the skin by evaporation. Wearing personal protective equipment (PPE) reduces the body's ability to eliminate heat because the evaporation of sweat is decreased. The body's ability to maintain temperature equilibrium becomes impaired.

Heat related problems include heat fatigue, heat rash, fainting, heat cramps, heat exhaustion and heat stroke. Heat rash occurs because sweat isn't evaporating, making the skin wet most of the time. Fainting may be caused by standing erect and immobile for extended periods of time when blood tends to pool in the lower extremities. Blood then returns more slowly to the heart to be pumped to the brain, causing dizziness or fainting.

Heat cramps are painful spasms of the muscles due to excessive salt loss associated with profuse sweating. The loss of large amounts of fluid and excessive loss of salt results in heat exhaustion. The skin will be clammy and moist and persons exhibit extreme wetness, giddiness, nausea and headache.

Heat stroke occurs when the body's temperature regulatory system has failed. Skin is hot, dry, red and spotted. The affected person may be mentally confused and delirious. Convulsions could occur. EARLY RECOGNITION AND TREATMENT OF HEAT STROKE ARE THE ONLY MEANS OF PREVENTING BRAIN DAMAGE OR DEATH. A person exhibiting signs of heat stroke should be removed from the work area to a shaded area. The person should be soaked with water to promote evaporation. Fan the person's body to increase cooling.

Increased body temperature and physical discomfort also promote irritability and a decreased attention to the performance of hazardous tasks.

Early Symptoms of Heat-Related Health Problems:

- decline in task performance
- incoordination
- decline in alertness
- unsteady walk
- excessive fatigue
- vigilance
- muscle cramps
- dizziness

Susceptibility to Heat Stress Increases due to:

- lack of physical fitness
- lack of acclimation
- increased age
- dehydration
- obesity
- drug or alcohol use
- sunburn
- infection

People unaccustomed to heat are particularly susceptible to heat fatigue. First time users in PPE need to gradually adjust to the heat.

Measures to Avoid Heat Stress:

- Establish work-rest cycles (short and frequ nt are more beneficial than long and seldom).
- Identify a shaded, cool rest area.
- Rotate personnel, alternative job functions.
- Water intake should be equal to the sweat produced. Most workers exposed to hot conditions drink less fluids than needed because of an insufficient thirst. DO NOT DEPEND ON THIRST TO SIGNAL WHEN AND HOW MUCH TO DRINK. For an 8-hour work day, 50 ounces of fluids should be drunk.
- Eat lightly salted foods or drink salted drinks such as Gatorade to replace lost salt.
- Save most strenuous tasks for non-peak heat hours such as the early morning or at night.
- Avoid alcohol during prolonged periods of heat. Alcohol will cause additional dehydration.
- Avoid double shifts and/or overtime.

The implementation and enforcement of the above mentioned measures will be the joint responsibility of the Project Manager, on-site field coordinator, and health and safety officer. Potable water and fruit juice will be available each day for the field team.

Site personnel should monitor their heart rate as an indicator of heat strain by the following method:

Radial pulse rates should be checked by using fore-and middle fingers and applying light pressure top the pulse in the wrist for one minute at the beginning of each rest cycle. If the pulse rate exceeds 110 beat/minute, the next work cycle will be shortened by one-third and the rest period will be kept the same. If, after the next rest period, the pulse rate still exceeds 110 beats/minute, the work cycle will be shortened again by one-third.

4.2.2 Operation of Heavy Equipment

Us of a drill rig to advance soil borings will require all personnel in the vicinity of the operating machinery to wear steel-toed footwear, hardhats, hearing protection and safety eyewear. Personnel should not remain in the vicinity of operating equipment unless it is required for their work responsibilities.

The estimated location of utility installations, such as sewer, telephone, electric, water lines and other underground installations that reasonably may be expected to be encountered during drilling or excavation activities, shall be determined by the contractor prior to drilling. Small stakes wrapped with flourescent tape or a similiar marker will be placed at the ends of each utility located within the specific areas of proposed investigation to alert personnel to the utility lines presence.

Equipment such as drill rigs which have the potential to come in contact with overhead power lines, must be positioned or operated so that they maintain a 10 feet minimum clearance of energized transmission lines.

4.2.3 Drilling Hazards

- All drill rigs and other machinery with exposed moving parts must be equipped with an operational emergency stop device. Drillers and geologists must be aware of the location of this device. This device must be tested prior to job initiation and periodically thereafter. The driller and helper shall not simultaneously handle augers unless there is a standby person to activate the emergency stop.

- The driller must never leave the controls while the tools are rotating unless all personnel are kept clear of rotating equipment.

- A long-handled shovel or equivalent must be used to clear drill cuttings away from the hole and from rotating tools. Hands and/or feet are not to be used for this purpose.

- A remote sampling device must be used to sample drill cuttings if the tools are rotating or if the tools are readily capable of rotating. Samplers must not reach into or near the rotating equipment. If personnel must work near any tools which could rotate, the driller must shut down the rig prior to initiating such work.

- Drillers, helpers and geologists must secure all loose clothing when in the vicinity of drilling operations.

- Only equipment which has been approved by the manufacturer may be used in conjunction with site equipment and specifically to attach sections of drilling tools together. Pins that protrude excessively from augers shall not be allowed

- No person shall climb the drill mast while tools are rotating.

- No person shall climb the drill mast without the use of ANSI-approved fall protection (approv d belts, lanyards and a fall protection slide rail) or portable ladder which meets the requirem nts of OSHA standards.

Table 1 summarizes the hazards associated with the proposed field investigation.

4.2.4 Potentially Explosive Atmospheres

If air monitoring (see Section 5.1.1) indicates that explosive atmospheres are present (>10% LEL) lights and tools used for the manhole inspection must be approved for use in Class 1, Division 2 atmosph res as defined by the National Fire Protection Association.

TABLE 1

TASK SPECIFIC HAZARD ASSESSMENT TABLE
REMEDIAL UST INVESTIGATION
COASTERS HARBOR ISLAND

Task	Hazard	Control Measures
Soil Boring Well Installation Sample Collection	Dermal Contact Thermal Stress Operation of Heavy Equipment	Use of PPE Appropriate Clothing; Work/Rest Cycles; Liquids; Site Access/Control
Manhole Inspection Soil Boring	Explosive Atmospheres Operation of Heavy Equipment Dermal Contact	Continuous Monitoring; Use of PPE; Site Access/Control Work/Rest Cycles; Liquids
Equipment Decontamination	Dermal Contact (wet conditions)	Water Resistance Clothing; Use of PPE

5.0 AIR MONITORING

5.1 DIRECT READING INSTRUMENTS

5.1.1 Explosive Atmospheres

Although fuel oils are not volatile at normal temperature and pressure, a combustible gas indicator (CGI) will be used screen the inside of the manhole. Whenever possible, the probe of the CGI will be inserted into the space below the cover to test the atmosphere, before the cover is removed. The probe should be inserted no more than 1 to 2 feet to avoid damage or contamination of the probe. If no gap for insertion is present, the cover should be carefully removed first and the atmosphere tested before lights or tools are used for inspection. If 10% of the lower explosive limit (LEL) is detected, the inspection process shall stop. The hole shall be left open and the probe should be left in place until the reading drops and remains below 10% LEL. Workers shall not wait near the hole during this period (minimum of 20' away).

If initial readings are below 10% LEL, the inspection may proceed though the probe should remain in place until the hole is closed. If readings rise to above 10% LEL, work must stop and the above procedure should be followed. CGI testing is not required during soil boring operations except when in the vicinity of existing MW-2. Readings should be taken at regular intervals or depths during the advancement and after bore completion or refusal (bottom). If readings of 10% LEL or greater are indicated (taken at the top of the bore), work should stop and procedures as described above should be followed.

5.2 PERSONAL AIR SAMPLING

Personal air sampling will not be conducted during the proposed investigation.

6.0 PERSONAL PROTECTIVE EQUIPMENT

Personal protective equipment (PPE) will be donned as described below for the tasks covered by this HASP to protect employees from coming in direct contact with contamination.

6.1 PROTECTIVE CLOTHING

1. Hard Hat
2. Safety Glasses
3. Steel-toed work boots (with disposable over boots) or steel-toed rubber boots
4. Polycoated tyvek coveralls w/hoods
5. Latex gloves
6. Nitrile gloves
7. Cotton gloves

Manhole Inspection

Items: 2,3,7

Soil Borings/Well Installation/Sampling

Items:1,2,3,5,6

Since borings and samples are being collected from areas where fuel oils are present, dermal contact and splash hazards should be anticipated. If saturated soils or free product are encountered, Item 4 will be required. Otherwise, work clothes may be worn.

Equipment Decontamination

Items: 2,3,5,6

If a high pressure or steam cleaner is used to decontaminated heavy equipment, a hooded splash suit will be worn in addition to the above items by the worker performing the decontamination or other nearby workers.

6.2 RESPIRATORY PROTECTION

Respiratory protection will not be required during proposed site activities.

6.3 OTHER SAFETY EQUIPMENT

ENSR will bring the following additional safety equipment to the site:

- First aid kit
- Portable, hand-held eyewash bottle
- 2.5 pound A-B-C type fire extinguishers

First aid kits will be inspected to ensure adequate supplies are available prior to leaving for the Site. In the event that this project is longer than one week in duration, the SSO will inspect the kit at least once a week and replace depleted materials as needed.

7.0 SITE CONTROL

To prevent both exposure of unprotected personnel and migration of contamination due to tracking by personnel or equipment, work areas and associated personal protective equipment requirements will be clearly identified.

7.1 WORK ZONES

The HALLIBURTON NUS Team designates work areas or zones as suggested in the "Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities," NIOSH/OSHA/USCG/EPA, November, 1985. They recommend the areas surrounding each of the work areas to be divided into three zones:

- Exclusion or "Hot" Zone
- Contamination Reduction Zone (CRZ)
- Support Zone

7.1.1 Exclusion Zone

An exclusion zone will be established at each area of investigation and will extend at least 20 feet from the center of work activity. All personnel entering the exclusion zone must wear the prescribed level of protective equipment. Exclusion zones will be marked with flagging tape so non-participating base personnel will be alerted to stay clear of the area.

7.1.2 Contamination Reduction Zone

A contamination reduction zone (CRZ) will be established for each bore advancement. This zone should act as an access control corridor to the exclusion zone as well as a decontamination area. Personnel will begin the sequential decontamination process (see Section 8.0) in this central decontamination zon .

7.1.3 Support Zone

Eating, drinking and smoking will only be allowed in this area and only after employees have completed proper personnel decontamination procedures.

7.2 PROTECTIVE MEASURES

The following measures are designed to augment the specific health and safety guidelines provided in this plan.

- The "buddy system" will be used at all times by all field personnel. No one is to perform investigative activities alone. All field team members must be intimately familiar with the procedures for initiating an emergency response.

- Avoidance of contamination is of the utmost importance. Wh never possible, avoid contact with contaminated (or potentially contaminated) surfaces or materials. Walk around (not through) puddles and discolored surfac s. Do not kneel on the ground or set equipment on the ground. Protect equipment from water and contamination by bagging.

- Eating, dr ing, chewing gum or tobacco, smoking or any practice that increases the probability of hand-to-mouth transfer and ingestion of materials is prohibited in the exclusion and contamination reduction zone.

- Hands and face must be thoroughly washed upon leaving the work area and before eating, drinking or any other activities.

- The use of alcohol or illicit drugs is prohibited during the conduct of field operations.

- All equipment must be decontaminated or properly discarded before leaving the site.

- An OSHA poster (Form 2203) will be brought to the work location. Such a poster is presented in Attachment C.

- The use of contact lenses is prohibited.

- All electrical tools must be connected to a ground fault interrupter and/or must be grounded with a third wire and the cord set must be double insulated and in good working condition.

8.0 DECONTAMINATION

Proper decontamination is required of all personnel and equipment before leaving the site. Personnel decontamination will be accomplished by following a systematic procedure of removing PPE. A three basin washing system will be set up for decontaminating chemically-resistant steel-toed boots in the event that "nuke boots" are not used. Minimally, this system will be used at the end of each day if boots are re-donned between borings without cleaning. (Boots must not be grossly contaminated, and must be transported in a disposable bag or other container.) The decontamination procedures for sampling equipment are presented in the project sampling plan.

Disposable PPE, such as Tyvek coveralls, gloves, outer boots, etc. will be disposed of in plastic bags. Bags will be left with the Navy for proper disposal.

Decontamination Procedures

1. Remove and wipe clean hard hat (if worn, if not, skip to 2)
2. Remove outer yellow,latex boots (if worn, if not, skip to 3)
3. Remove outer gloves
4. Remove tyvek coveralls (if worn, if not, skip to 5)
5. Remove inner gloves
6. Clean chemically resistant boots in wash basins

Boots that have been washed clean can be worn into the support zone or off-site.

A cooler of potable water will be dedicated for hand and face washing. Liquid soap and hand towelettes will be available.

Decontamination fluids will be collected on site, drummed and labeled for disposal in accordance with th Work Plan and will be left with the Navy for proper disposal.

9.0 MEDICAL MONITORING/TRAINING REQUIREMENTS

9.1 MEDICAL MONITORING

All personnel performing activities on this site covered by this HASP must be active participants in ENSR's Medical Monitoring Program or in a similar HALLIBURTON NUS program which complies with 29 CFR 1910.120(f). Each individual must have completed an annual surveillance examination and/or an initial baseline examination within the last year prior to performing any work on this site covered by this HASP. No site specific monitoring is required.

9.2 TRAINING

Additionally, all personnel performing activities on this site covered by this HASP must have completed the appropriate training requirements specified in 29 CFR 1910.120(e). Each individual must have completed an annual 8-hour refresher training course and/or initial 40-hour training course within the last year prior to performing any work on this site covered by this HASP. Also, onsite managers and supervisors directly responsible for supervising individuals engaged in hazardous waste operations must have completed the specified 8-hour managers training course. (Note that ENSR corporate policy requires that whenever three or more ENSR employees are performing work on the same site, at least one of these individuals must have completed the manager's training course.)

Although not required under 29 CFR 1910, it is recommended that one person qualified in First Aid and CPR be present during all site work.

HALLIBURTON NUS Field Team members and subcontractors to the HALLIBURTON NUS Team will be required to provide to the Team's CHSO signed Subcontractor Medical Approval and Compliance Forms, SOP MD-02, for each individual assigned to this project indicating that they have completed the medical monitoring and training requirements specified above. The PM will forward this information to the CHSM. This information must be provided prior to their performing any work onsite. The appropriate Subcontractor Forms are provided in Attachment D.

9.3 PRE-ENTRY BRIEFING

Prior to the commencement of on-site investigative activities, a site safety meeting will be held to review the specific requirements of this HASP. HASP sign-off sheets will be collected at this meeting, if they have not yet been submitted to the HALLIBURTON NUS PM. Short safety refresher meetings will be conducted, as needed, throughout the duration of the project. Attendance of this meeting will be documented. An attendance sign-in form is presented in Attachment E.

The following information should be covered in the pre-entry briefing:

- General Overview of HASP
- Names of Personnel and Alternates Responsible for Health and Safety
- Chemical and Physical Hazards Associated with Site Activities
- Personal Protective Equipment Required for Site Activities
- Use of Air Monitoring Equipment
- Site Emergency Procedures
- Training and Medical Surveillance Requirements
- Signs and Symptoms of Overexposure
- Review of MSDSs for Decontamination Solutions
- Risk minimizing work practices
- Uses of safety equipment

10.0 EMERGENCY RESPONSE

OSHA defines **emergency response** as any "response effort by employees from outside the immediate release area or by other designated responders (i.e., mutual-aid groups, local fire departments, etc.) to an occurrence which results, or is likely to result in an **uncontrolled release of a hazardous substance.**" According to the HALLIBURTON NUS Team policy, HALLIBURTON NUS personnel shall not participate in any emergency response where there are potential safety or health hazards (i.e., fire, explosion, or chemical exposure). HALLIBURTON NUS response actions will be limited to evacuation and medical/first aid as described within this section below. Accordingly, this section of the HASP has been written to meet the requirements of 29 CFR 1910.38 (a).

The basic elements of an emergency evacuation plan include employee training, alarm systems, escape routes, escape procedures, critical operations or equipment, rescue and medical duty assignments, designation of responsible parties, emergency reporting procedures and methods to account for all employees after evacuation.

Empl yee Training: General training regarding emergency evacuation procedures are included in the ENSR initial and refresher training as described above in Section 9.0 of this Health and Safety Plan (HASP). Also as described above in Section 9.3, employees must be instructed in the specific aspects of emergency evacuation applicable to the site as part of the site safety meeting prior to the commencement of all on-site activities. On-site refresher or update training is required anytime escape routes or procedures are modified or personnel assignments are changed.

Alarm Systems/Emergency Signals: An emergency communication system must be in effect at all sites. The most simple and effective emergency communication system in many situations will be **direct v rbal communications**. Each site must be assessed at the time of initial site activity and periodically as the work progresses. Verbal communications must be supplemented anytime voices can not be clearly perceived above ambient noise levels (e.g., noise from heavy equipment) and anytime a clear-line-of-sight can not be easily maintained amongst all ENSR personnel because of distance, terrain or other obstructions.

Em rgency Signals (using hand held portable airhorns) shall be implemented to warn employees of an emergency whenever direct verbal communication is not maintained. The horn-blast signal codes below, shall be used:

- **ONE HORN BLAST: GENERAL WARNING**

One horn blast is used to signal relatively minor, yet important events on-site. An example of this type of event would be a minor chemical spill where there is no immediate danger to life or health yet personnel working on-site should be aware of the situation so unnec ssary problems can be avoided. If one horn blast is sounded personnel must stop all activity and equipment on-site and await further instructions from the on-site PM or SSO.

- **TWO HORN BLASTS: MEDICAL EMERGENCY**

Two horn blasts are used to signal a medical emergency where immediate first-aid or emergency medical care is required. If two horn blasts are sounded all first-aid and/or CPR trained personnel should respond as appropriate, all other activity and equipment should stop and personnel should await further instructions from the on-site PM or SSO.

- **THREE HORN BLASTS FOLLOWED BY ONE CONTINUOUS BLAST: IMMEDIATE DANGER TO LIFE OR HEALTH**

Three horn blasts followed by another extended or continuous horn blast signals a situation which could present an immediate danger to the life or health (IDLH) of all personnel on-site. Examples of possible IDLH situations could include fires, explosions, hazardous chemical spills or releases, hurricanes, tornadoes, blizzards or floods. If three horn blasts followed by a continuous blast are sounded, all activity and equipment must stop, and all personnel must evacuate the site to an appropriately designated site located either outside the immediate area of emergency or off-site. (Note: Unless otherwise specified, all decontamination procedures must be implemented.) All personnel must be accounted for by the SSO and other response actions determined by the SSO must be observed.

Escape Routes and Procedures: The escape route from the site will be via Gate 1. The assembly area after evacuating the site will be the main gate (Gate 1) prior to exiting the facility.

Critical Operations or Equipment: All equipment and operations are required to cease in accordanc with the established signal procedure. The only exception will be related to health and safety. The PM or SSO must determine at the time of an emergency if health and safety will be jeopardized by immediat stoppage of any particular piece of equipment or personal activities. If such a determination is mad , p rsonnel involved in critical duties must be minimized and special instructions must be established.

R scue and Medical Duty Assignments: The phone numbers of the police and fire departments, ambulance service, local hospital, and HALLIBURTON NUS Team representatives are provided in the mergency reference sheet on the last page of the HASP. Directions to the hospital should be taped to the dashboard of all on site vehicles that may be used for emergency transport.

The SSO is responsible for activating emergency response actions. In the event an injury or illness requires more than first aid treatment, that individual will accompany the injured person to the medical facility and will remain with the person until release or admittance is determined. The escort will relay all appropriate medical information to the on-site project manager and the CHSO. The CHSO will notify the CHSM.

If the injured employee can be moved from the accident ar a, he or she will be brought to the CRZ where their PPE will be removed. If the person is suffering from a back or neck injury the person will not be moved and the requirements for decontamination do not apply. The SSO must familiarize the responding emergency personnel about the nature of the site and the injury. If the responder feels that the PPE can be cut away from the injured persons body, this will be done on-site. If this not feasible, decontamination will be performed after the injured person has been stabilized.

D signation of Responsible Parties: The SSO is responsible for initiating emergency response. In the event the SSO can not fulfill this duty, the alternate SSO will take charge. All personnel onsite are responsible for knowing the escape route from the site.

Accident Investigation: Any incident (other than minor first aid treatment) resulting in injury, illness or property damage requires an accident investigation and report. The investigation will be initiated as soon as emergency conditions are under control. The purpose of the investigation is not to attribute blame but to det rmine the pertinent facts so that repeat or similiar occurrences can be avoided.

Th investigation should begin while details are fresh in the mind of anyone involved. The person administering first aid may be able to start the fact gathering process if the injured are able to speak. Pertinent facts must be determined. Questions beginning with who, what, when, where and how are usually most effective to discover ways to improve job performance in terms of efficiency, qualtiy of work, as w ll as health and safety concerns.

An accident investigation form (for use by ENSR personnel only) is presented in Attachment F of this document.

Reporting requirements: In the event of an emergency, the SSO is required to report to the CHSO who in turn will report the incident to CHSM.

EMERGENCY REFERENCE

FIRE:	**911 r Naval Resp nse Number (to be det rmin d)**
POLICE:	**911 or Naval Response Number (to be determined)**
AMBULANCE:	**401-846-6400**
HOSPITAL:	**Newport Hospital, Newport Rhode Island**

DIRECTIONS TO THE HOSPITAL: Leave island via Rt. 114, Gate 1. Go straight on Van Zandt Ave. At Broadway (Route 114) turn right and go to Friendship Street (next light) and turn left and follow signs to Hospital Emergency Entrance.

NATIONAL RESPONSE CENTER: **1-800-424-8802**

HALLIBURTON NUS TEAM REPRESENTATIVES:

ENSR/ACTON, MA	508-635-9500
-Bill Trabilcy (CHSO)	x 3326
-Charles Martin (FTL)	x 3378
-[illegible]ail Scott (PM)	x 3118
- TBA (SSO)	
- TBA (Alternate SSO)	
HALLIBURTON NUS	412-921-7090
-Matthew Soltis (CHSM)	412-921-8912

11.0 SPILL CONTINGENCY PLAN

It is possible that the sample equipment decontamination solutions may spill during transport across the site or use on-site. The containers will be stored in a pan or tray so that if the bottles should leak, the material will be contained.

ATTACHMENT A
HASP SIGN-OFF SHEET

Health and Safety Plan
For
Field Sampling Program
at
Coaster's Harbor Island

Newport, Rhode Island

I the undersigned have received a copy of the above referenced document. I have read this document and understand its contents and requirements. I agree to abide by the requirements of this health and safety plan.

____
Signature

____
Date

____
Representing

ATTACHMENT B
MATERIAL SAFETY DATA SHEETS

American Burdick & Jackson
Material Safety Data Sheet

MATERIAL SAFETY DATA SHEET

ACETONE

emergency telephone no. 312/973-3600 (American Scientific Products)
chemtrec telephone no. 800/424-9300
information telephone no 616/726-3171 (American Burdick & Jackson)

I. Identification

chemical name: Acetone — molecular weight: 58.08
chemical family: Ketone — formula: C_3H_6O
synonyms: Dimethyl Ketone
DOT proper shipping name: Acetone
DOT hazard class: Flammable Liquid
DOT identification no.: UN1090 — CAS no: 67-64-1

II. Physical and Chemical Data

boiling point, 760mm Hg: 56.29°C — freezing point: -94.7°C — evaporation rate: (BuAc=1)ca 12
vapor pressure at 20°C: 184.5 mm Hg — vapor density (air = 1): 2.0 — solubility in water: @ 20 C c mplete
% volatiles by volume: ca 100 — specific gravity (H_2O = 1): @ 20°C 0.79 — stability: Stable
hazardous polymerization: Not expected to occur.
appearance and odor: Clear, colorless liquid with a penetrating, sweet odor.
conditions to avoid: Heat, sparks, open flame, open containers, and poor ventilation.

materials to avoid: Strong oxidizing agents and strong acids and bases.

hazardous decomposition products: Incomplete combustion can generate carbon monoxide and other t x vapors.

III. Fire and Explosion Hazard Data

flash point, (test method): -18°C (Tag closed cup) — auto ignition temperature: 465°C
flammable limits in air % by volume lower limit: 2.6 — upper limit: 12.8
unusual fire and explosion hazards: Very volatile and extremely flammable. Mixtures with water can b flammable.

extinguishing media: Carbon dioxide, dry chemical, alcohol foam, water mist or fog.

special fire fighting procedures: Wear full protective clothing and self-contained br athing apparat
Heat will build pressure and may rupture closed storage c ntainers
Keep fire-exposed containers cool with water spray.

IV. Hazardous Components

	%	TLV	CAS no.
Acetone	ca 100	750 ppm	67-64-

American Burdick & Jackson's Disclaimer: "The information and recommendations presented herein are based on sources believed reliable as of the date hereof American Burdick & Jackson makes no representation as to the completeness or accuracy thereof. It is the user s respons to determine the product s suitability for its intended use. the product s safe use. and the product s proper disposal No representations or warrantie expressly set forth herein are made hereunder. whether express or implied by operation of law or otherwise, including, but not limited to any implied warr of MERCHANTABILITY OR FITNESS American Burdick & Jackson neither assumes nor authorizes any other person to assume for it, any other or ADDIT! LIABILITY OR RESPONSIBILITY resulting from the use of, or reliance upon, this information

American Burdick & Jackson
Subsidiary of American Hospital Supply Corporation
1953 South Harvey Street
Muskegon MI 49442

V. Health Hazards

Occupational Exposure Limits

OSHA	8-hour PEL	-	1000 ppm
	Ceiling	-	not listed
	Peak	-	not listed
ACGIH	TLV-TWA	-	750 ppm
	TLV-STEL (15-min)	-	1000 ppm
NIOSH	TLV-TWA	-	250 ppm
	TLV-C	-	not listed

Concentration Immediately Dangerous to Health

OSHA/NIOSH	20,000 ppm

Odor Threshold

NSC	2 ppm
NIOSH	not listed

Carcinogenic, Mutagenic, Teratogenic Data

Positive mutagen (RTEC)

Primary Routes of Entry

Acetone may exert its effects through inhalation, skin absorption, and ingestion.

Industrial Exposure: Route of Exposure/Signs and Symptoms

Inhalation:	Exposure can cause eye, nose, and throat irritation, headache, nausea, dizziness and narcosis.
Eye Contact:	Liquid and high vapor concentration can cause irritation.
Skin Contact:	Prolonged or repeated skin contact can cause irritation and dermatitis through defatting of skin.
Ingestion:	Symptom information is inadequate/unknown.

Effects of Overexposure

Acetone is a mild eye and mucous membrane irritant, primary irritant, and central nervous system depressant. Acute exposure irritates the eyes and upper respiratory tract. Direct skin contact produces dermatitis, characterized by dryness and erythema. High concentrations produce narcosis and hypoglycemia.

Medical Condition Aggravated by Exposure

Preclude from exposure those individuals susceptible to dermatitis.

Emergency First Aid

Inhalation:	Immediately remove to fresh air. If not breathing, administer mouth-to-mouth rescue breathing. If there is no pulse administer cardiopulmonary resuscitation (CPR). Contact physician immediately.
Eye Contact:	Rinse with copious amounts of water for at least 15 minutes. Get emergency medical assistance.
Skin Contact:	Flush thoroughly for at least 15 minutes. Wash affected skin with soap and water. Remove contaminated clothing and shoes. Wash clothing before re-use, and discard contaminated shoes. Get emergency medical assistance.
Ingestion:	Call local Poison Control Center for assistance. Contact physician immediately. Never induce vomiting or give anything by m uth to a victim unconscious or having convulsions.

VI. Safety Measures and Equipment

Ventilation:	Adequate ventilation is required to protect personnel from exposure to chemical vapors exceeding the PEL and to minimize fire hazards. The choice of ventilation equipment, either local or general, will depend on the conditions of use, quantity of material, and other operating parameters.
Respiratory:	Use approved respirator equipment. Follow NIOSH and equipment manufacturer's recommendations to determine appropriate equipment (air-purifying, air-supplied, or self-contained breathing apparatus).
Eyes:	Safety glasses are considered minimum protection. Goggles r face shield may be necessary depending on quantity of material and conditions of use.
Skin:	Protective gloves and clothing are recommended. The ch ice of material must be based on chemical resistance and other user requirements. Generally, neoprene or rubber offers acceptable chemical resistance. Individuals who are acutely and specifically sensitive to acetone may require additional protective equipment.
Storage:	Acetone should be protected from temperature extremes and direct sunlight. Proper storage of acetone must be determined based on other materials stored and their hazards and potential chemical incompatibility. In general, acetone should be st red in an acceptably protected and secure flammable liquid storage room.

Other:	Emergency ey wash fountains and safety showers should be available in the vicinity of any potential exposure. Ground and bond metal containers to minimize static sparks.

VII. Spill and Disposal Data

Spill Control:	Protect from ignition. Wear protective clothing and use appr ved respirator equipment. Absorb spilled material in an absorbent recommended for solvent spills and remove to a safe location for disposal by approved methods. If released to the environment, comply with all regulatory notification requirements.
Waste Disposal:	Dispose of acetone as an EPA hazardous waste. Hazardous waste numbers: U002(Ignitable); D001(Ignitable).

Revision Date: 1/85

KEY

ca	Approximately	STEL	Short Term Exposure Level
na	Not applicable	TLV	Threshold Limit Value
C	Ceiling	TWA	Time Weighted Average
PEL	Permissable Exposure Level	BuAc	Butyl Acetate

NSC Nati nal Safety Council ("Fundamentals of Industrial Hygi ne", 1983)
OHS Occupational Health Services ("Hazardline")

Baxter Healthcare Corporation
Burdick & Jackson Division
1953 South Harvey Street
Muskegon, MI 49442 USA

information/emergency telephone no 616.726.3171
chemtrec telephone no 800 424 9300
canadian emergency telephone no 613.996.6666

MATERIAL SAFETY DATA SHEET

METHANOL

I. Identification

chemical name	Methanol
molecular weight	32.04
chemical family	Alcohol
formula	CH_4O
synonyms	Carbinol, Methyl Alcohol, Wood Alcohol
DOT proper shipping name	Methyl Alcohol or Methanol
DOT hazard class	Flammable Liquid
DOT identification no	UN1230
CAS no	67-56-1

II. Physical and Chemical Data

boiling point, 760mm Hg	64.7°C
freezing point	-97.7°C
evaporation rate	(BuAc=1) ca 5
vapor pressure at 20°C	97 mm Hg
vapor density (air=1)	1.11
solubility in water	@ 20°C complete
% volatiles by volume	ca 100
specific gravity (H_2O=1)	@ 20°C 0.792
stability	Stable

hazardous polymerization: Not expected to occur.

appearance and odor: A clear, colorless liquid with a slight alcoholic odor.

conditions to avoid: Heat, sparks, open flame, open containers, and poor ventilation.

materials to avoid: Strong oxidizing agents and reactive metals which will displace hydrogen.

hazardous decomposition products: Incomplete combustion can generate carbon monoxide and other toxic vapors such as formaldehyde.

III. Fire and Explosion Hazard Data

flash point (test method): 12°C (Tag closed cup)

auto ignition temperature: 385°C

flammable limits in air % by volume: lower limit 6.7 upper limit 36.5

unusual fire and explosion hazards: May burn with an invisible flame. Mixtures with water as low as 21% by volume are still flammable (flash point below 37.8°C). Under some circumstances can corrode certain metals, including aluminum and zinc, and generate hydrogen gas.

extinguishing media: Carbon dioxide, dry chemical, alcohol foam, water mist or fog.

special fire fighting procedures: Wear full protective clothing and self-contained breathing apparatus. Heat will build pressure and may rupture closed storage containers. Keep fire-exposed containers cool with water spray.

IV. Hazardous Components

Component	%	TLV	CAS no.
Methanol	ca 100	200 ppm (skin)	67-56-1

V. Health Hazards

Occupational Exposure Limits

OSHA	TWA	- 200 ppm
	STEL	- 250 ppm
	Ceiling	- not listed
ACGIH	TLV-TWA	- 200 ppm
	TLV-STEL	- 250 ppm
NIOSH	10 hour TWA	- 200 ppm
	15 min Ceiling	- 800 ppm

Concentration Immediately Dangerous to Health

OSHA/NIOSH	25,000 ppm

Odor Threshold

NSC	10 ppm
NIOSH	2000 ppm

Carcinogenic Data

Methanol is not listed as a carcinogen by IARC, NTP, OSHA, or ACGIH.

Primary Routes of Entry

Methanol may exert its effects through inhalation, skin absorption, and ingestion.

Industrial Exposure: Route of Exposure/Signs and Symptoms

Inhalation: Exposure can cause drowsiness and intoxication, headache, visual disturbance leading to blindness, coughing and shortness of breath, collapse and death at high concentrations.

Eye Contact: Liquid can cause moderate burning, watering, swelling, and redness; high vapor concentration (greater than 2000 ppm) may cause same symptoms.

Skin Contact: This substance may be absorbed through intact skin and produce toxic effects. Extensive, repeated and/or prolonged skin contact can cause burning, itching, redness, or blisters.

Ingestion: Causes burning of the gastrointestinal tract and toxic effects. Swallowing more than 2 ounces of methanol can cause death.

Effects of Overexposure

Mild poisoning is characterized by fatigue, nausea, headache, and delayed visual blurring. Moderate intoxication results in severe depression. Temporary or permanent blindness may follow in 2-6 days. In severe poisoning, symptoms progress to rapid, shallow respiration, cyanosis, coma, hypotension, dilated pupils, and visual disturbance. Death may result from respiratory failure.

Medical Condition Aggravated by Exposure

Preclude from exposure those individuals with diseases of eyes, liver, kidneys, and lungs.

Emergency First Aid

Inhalation: Immediately remove to fresh air. If not breathing, administer mouth-to-mouth rescue breathing. If there is no pulse administer cardiopulmonary resuscitation (CPR). Contact pnysician immediately.

Eye Contact: Rinse with copious amounts of water for at least 15 minutes. Get emergency medical assistance.

Skin Contact: Flush thoroughly for at least 15 minutes. Wash affected skin with soap and water. Remove contaminated clothing and shoes. Wash clothing before re-use, and discard contaminated shoes. Get emergency medical assistance.

Ingestion: Call local Poison Control Center for assistance. Contact physician immediately. Never induce vomiting or give anything by mouth to a victim unconscious or having convulsions.

Note to Physician

In case of ingestion or massive inhalation, observe victim as an inpatient because slow metabolism causes a latent period of 24 hours between exposure and acidosis and blindness.

VI. Safety Measures and Equipment

Ventilation: Adequate ventilation is required to protect personnel from exposure to chemical vapors exceeding the PEL and to minimize fire hazards. The choice of ventilation equipment, either local or general, will depend on the conditions of use, quantity of material, and other operating parameters.

Respiratory: Use approved respirator equipment. Follow NIOSH and equipment manufacturer's recommendations to determine appropriate equipment (air-purifying, air-supplied, or self-contained breathing apparatus).

Eyes: Safety glasses are considered minimum protection. Goggles or face shield may be necessary depending on quantity of material and conditions of use.

Skin: Protective gloves and clothing are recommended. The choice of material must be based on chemical resistance and other user requirements. Generally, neoprene, nitrile rubber, or rubber offer acceptable chemical resistance. Individuals who are acutely and specifically sensitive to methanol may require additional protective equipment.

Storage:	Methanol should be protected from temperature extrem s and direct sunlight. Proper st rage of methan l must be determined based on other materials stored and their hazards and potential chemical incompatibility. In general, methanol should be stored in an acceptably protected and secure flammable liquid storage room.
Other:	Emergency eye wash fountains and safety showers should be available in the vicinity of any potential exposure. Ground and bond metal containers to minimize static sparks.

VII. Spill and Disposal Data

Spill Control:	Protect from ignition. Wear protective clothing and use approved respirator equipment. Absorb spilled material in an absorbent recommended for solvent spills and remove to a safe location for disposal by approved methods. If released to the environment, comply with all regulatory notification requirements. CERCLA Reportable Quantity — 5,000 lbs.
Waste Disposal:	Dispose of methanol as an EPA hazardous waste. Contact state environmental agency for listing of licensed hazardous waste disposal facilities and applicable regulations. Hazardous waste numbers: U154(Ignitable); D001(Ignitable).

VIII. SARA/Title III Data

Hazard Classification	
Immediate Health	Yes
Delayed Health	Yes
Fire	Yes
Sudden Release	No
Reactive	No

Chemical Listings	
Extremely Hazardous Substances	N
CERCLA Hazardous Substances	Yes
Toxic Chemicals	Y s

Methanol is subject to the reporting requirements of Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA) and 40CFR Part 372. This product does not contain any other toxic chemical above 1% concentration or a carcinogen above 0.1% concentration.

Revision Date: July, 1989

KEY

ca	Approximately	STEL	Short Term Exposure Level (15 minutes)
na	Not applicable	TLV	Threshold Limit Value
C	Ceiling	TWA	Time Weighted Average (8 hours)
		BuAc	Butyl Acetate

CERCLA Comprehensive Environmental Response, Compensation and Liability Act
NSC National Safety Council ("Fundamentals of Industrial Hygiene." 3rd Ed., 1988)

ATTACHMENT C
OSHA POSTER

JOB SAFETY & HEALTH PROTECTION

The Occupational Safety and Health Act of 1970 provides job safety and health protection for workers by promoting safe and healthful working conditions throughout the Nation. Provisions of the Act include the following:

Employers

All employers must furnish to employees employment and a place of employment free from recognized hazards that are causing or are likely to cause death or serious harm to employees. Employers must comply with occupational safety and health standards issued under the Act.

Employees

Employees must comply with all occupational safety and health standards, rules, regulations and orders issued under the Act that apply to their own actions and conduct on the job.

The Occupational Safety and Health Administration (OSHA) of the U.S. Department of Labor has the primary responsibility for administering the Act. OSHA issues occupational safety and health standards, and its Compliance Safety and Health Officers conduct jobsite inspections to help ensure compliance with the Act.

Inspection

The Act requires that a representative of the employer and a representative authorized by the employees be given an opportunity to accompany the OSHA inspector for the purpose of aiding the inspection.

Where there is no authorized employee representative, the OSHA Compliance Officer must consult with a reasonable number of employees concerning safety and health conditions in the workplace.

Complaint

Employees or their representatives have the right to file a complaint with the nearest OSHA office requesting an inspection if they believe unsafe or unhealthful conditions exist in their workplace. OSHA will withhold, on request, names of employees complaining.

The Act provides that employees may not be discharged or discriminated against in any way for filing safety and health complaints or for otherwise exercising their rights under the Act.

Employees who believe they have been discriminated against may file a complaint with their nearest OSHA office within 30 days of the alleged discriminatory action.

Citation

If upon inspection OSHA believes an employer has violated the Act, a citation alleging such violations will be issued to the employer. Each citation will specify a time period within which the alleged violation must be corrected.

The OSHA citation must be prominently displayed at or near the place of alleged violation for three days, or until it is corrected, whichever is later, to warn employees of dangers that may exist there.

Proposed Penalty

The Act provides for mandatory civil penalties against employers of up to $7,000 for each serious violation and for optional penalties of up to $7,000 for each nonserious violation. Penalties of up to $7,000 per day may be proposed for failure to correct violations within the proposed time period and for each day the violation continues beyond the prescribed abatement date. Also, any employer who willfully or repeatedly violates the Act may be assessed penalties of up to $70,000 for each such violation. A minimum penalty of $5,000 may be imposed for each willful violation. A violation of posting requirements can bring a penalty of up to $7,000.

There are also provisions for criminal penalties. Any willful violation resulting in the death of any employee, upon conviction, is punishable by a fine of up to $250,000 (or $500,000 if the employer is a corporation), or by imprisonment for up to six months, or both. A second conviction of an employer doubles the possible term of imprisonment. Falsifying records, reports, or applications is punishable by a fine of $10,000 or up to six months in jail or both.

Voluntary Activity

While providing penalties for violations, the Act also encourages efforts by labor and management, before an OSHA inspection, to reduce workplace hazards voluntarily and to develop and improve safety and health programs in all workplaces and industries. OSHA's Voluntary Protection Programs recognize outstanding efforts of this nature.

OSHA has published Safety and Health Program Management Guidelines to assist employers in establishing or perfecting programs to prevent or control employee exposure to workplace hazards. There are many public and private organizations that can provide information and assistance in this effort, if requested. Also, your local OSHA office can provide considerable help and advice on solving safety and health problems or can refer you to other sources for help such as training.

Consultation

Free assistance in identifying and correcting hazards and in improving safety and health management is available to employers, without citation or penalty, through OSHA-supported programs in each State. These programs are usually administered by the State Labor or Health department or a State university.

Posting Instructions

Employers in States operating OSHA approved State Plans should obtain and post the State's equivalent poster.

Under provisions of Title 29, Code of Federal Regulations, Part 1903.2(a)(1) employers must post this notice (or facsimile) in a conspicuous place where notices to employees are customarily posted.

More Information

Additional information and copies of the Act, specific OSHA safety and health standards, and other applicable regulations may be obtained from your employer or from the nearest OSHA Regional Office in the following locations:

Atlanta, GA	(404) 347-3573
Boston, MA	(617) 565-7164
Chicago, IL	(312) 353-2220
Dallas, TX	(214) 767-4731
Denver, CO	(303) 844-3061
Kansas City, MO	(816) 426-5861
New York, NY	(212) 337-2378
Philadelphia, PA	(215) 596-1201
San Francisco, CA	(415) 744-6670
Seattle,WA	(206) 442-5930

Lynn Martin

Lynn Martin, Secretary of Labor

Washington, DC
1991 (Reprinted)
OSHA 2203

U.S. Department of Labor

Occupational Safety and Health Administration

ATTACHMENT D
SUBCONTRACTOR FORMS

EXAMPLE

OSHA Compliance Letter

The following statements must be typed on company letterhead and signed by an officer of the Company:

Company Name
Address

Date

William Trabilcy
ENSR Consulting and Engineering
HALLIBURTON NUS Team
35 Nagog Park
Acton, Ma. 01720

Subject: OSHA Compliance: Coaster's Harbor Island Site
Newport, Rhode Island

Dear William;

As an officer of (insert Company name), I hereby state that I am aware of the potential hazardous nature of the subject project. I also understand that it is our reponsibility to comply with all applicable occupational safety and health regulations including those stipulated in Title 29 of the Code of Federal Regulations (CFR), Parts 1900 through Part 1926.

I also understand that 29 CFR 1910.120, Hazardous Waste Operations and Emergency Response Standard, requires medical surveillance, for applicable employees and appropriate levels of training as required by paragraph (e) of the standard for employees engaged in certain hazardous waste operations. In this regard, I hereby state that I have reviewed these requirements and that (insert Company name) and all of its employees who will perform work at (insert site location) are in full compliance with the applicable requirements.

Sincerely,

(Name of Company Officer)

EXAMPLE

OSHA Training Certification

The following statements must be typed on company letterhead and signed by an officer of the company:

Name of Company
Address

Date

William Trabilcy
ENSR Consulting and Engineering
HALLIBURTON NUS Team
35 Nagog Park
Acton, Ma. 01720

Subject: Hazardous Waste Training, Coaster's Harbor Island, Newport, RI

Dear William;

The employees listed below have had initial 40 hour hazardous waste operation training as required by 29 CFR 1910.120 (e)(3). In addition, those employees listed below who have received their initial training more than 12 months ago have also received 8 hours of refresher training in accordance with 29 CFR 1910.120 (e)(8).

List full names of employees and their social security numbers and the dates of training

Should you have any questions, please call me at (insert company phone number).

Sincerely,

(Name of Company Officer)

EXAMPLE

M dical Surveillance L tter

The following statements must be typed on company letterhead and signed by an officer of the company and accompanied by the attached Subcontrator Medical Approval Form or equivalent for each employee assigned to the Coaster's Harbor Island Site, Newort, RI. Each employee must also complete the attached Medical Data Sheet.

Company Name
Address

Date

William Trabilcy
ENSR Consulting and Engineering
HALLIBURTON NUS Team
35 Nagog Park
Acton, Ma. 01720

Subject: Medical Surveillance: Coaster's Harbor Island Site, Newport, RI

Dear William;

As an officer of (insert company name), I hereby state that the persons listed below participate in a medical surveillance program meeting the requirements of paragraph (f) of 29 CFR 1910.120, "Hazardous Waste Operations and Emergency Response Standard". I further state that the persons listed below have had physical examinations under this program within the past 12 months and that they have been cleared, by a licensed physician, to perform hazardous waste site work and to wear positive and negative pressure respiratory protection. I also state that, to my knowledge, no person listed below has any medical restriction that would preclude him/her from working at the (insert site name).

List full name of employees and social security numbers and date of last examination here.

Should you have any questions, please contact me at (insert company phone number).

Sincerely,

(Name of Company Officer)

ATTACHMENT E
PRE-ENTRY BRIEFING ATTENDANCE SHEET

HEALTH AND SAFETY PLAN PRE-ENTRY BRIEFING ATTENDANCE FORM

For the
Sampling Program
at
Coaster's Harbor Island
Newport, Rhode Island

Briefing Conducted By: ____________________

Date Performed: ____________________

Printed Name	Signature	Representing

ATTACHMENT F
ACCIDENT INVESTIGATION REPORT

ATTACHMENT 8.1 - SUPERVISOR'S ACCIDENT INVESTIGATION REPORT

Injured Employee ______________________ Job Title ______________

Home Office ________________ Division/Department ______________

Date/Time of Accident ____

Location of Accident ____

Witnesses to the Accident ____________________________________

Injury Incurred? _____ Nature of Injury ______________________

____

Engaged in What Task When Injured? ___________________________

____

Will Lost Time Occur? _____ How Long? ________ Date Lost Time Began ________

Were Other Persons Involved/Injured? _________________________

____

How Did the Accident Occur? __________________________________

____

____

____

____

What Could Be Done to Prevent Recurrence of the Accident? ______

____

____

What Actions Have You Taken Thus Far to Prevent Recurrence? ____

____

____

Supervisor's Signature __________________ Title ____________ Date _____

Reviewer's Signature __________________ Title ____________ Date _____

N TE: IF THE SPACE PROVIDED ON THIS FORM IS INSUFFICIENT, PR VIDE ADDITIONAL INF RMATION ON SEPARATE PAPER AND ATTACH. THE COMPLETED ACCIDENT INVESTIGATION REPORT MUST SUBMITTED TO THE REGIONAL HEALTH AND SAFETY MANAGER WITHIN FIVE DAYS OF THE OCCURRENCE OF THE ACCIDENT.

APPENDIX C
STANDARD OPERATING PROCEDURES

List f SOP's Included in App ndix C

GH-1.3	Soil and Rock Sampling
GH-1.4	Soil and Rock Drilling
GH-1.5	Borehole and Sample Logging
GH-1.6	Decontamination of Drill Rigs and Monitoring Well Materials
GH-1.7	Groundwater Monitoring Point Installation
GH-2.5	Water Level Measurement/Contour Mapping
ME-01	HNU P1-101 Organic Vapor Meter
ME-02	OVA 128 Organic Vapor Analyzer
ME-11	General Calibration Requirements
SA-1.1	Groundwater Sample Acquisition
SA-6.2	Sample Packaging and Shipping
SA-6.3	Site Logbook
7600	Decontamination

NUS CORPORATION

ENVIRONMENTAL MANAGEMENT GROUP

STANDARD OPERATING PROCEDURES

Number	GH-1.3
Page	1 of 13
Effective Date	05/04/90
Revision	2
Applicability	EMG
Prepared	Earth Sciences
Approved	D. Senovich

Subject: SOIL AND ROCK SAMPLING

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1.0 PURPOSE

The purpose of this procedure is to identify the equipment, sequence of events, and appropriate methods necessary to obtain soil, both surface and subsurface, and rock samples during field sampling activities.

2.0 SCOPE

The methods described within this procedure are applicable while collecting surface and subsurface soil samples; obtaining rock core samples for lithologic and hydrogeologic evaluation; excavation/foundation design and related civil engineering purposes.

3.0 GLOSSARY

Hand Auger- A sampling device used to extract soil from the ground in a relatively undisturbed form.

Thin-Walled Tube Sampler - A thin-walled metal tube (also called Shelby tube) used to recover relatively undisturbed soil samples. These tubes are available in various sizes, ranging fr m 2 to 5 inches O.D. and 18 to 54 inches long. A stationary piston device may be included in the sampler to reduce sampling disturbance and increase sample recovery.

Split-Barrel Sampler - A steel tube, split in half lengthwise, with the halves held together by threaded c llars at either end of the tube. Also called a split-spoon sampler, this device can be driven into resistant materials using a drive weight mounted in the drilling string. A standard split spoon sampler (used for performing Standard Penetration Tests) is 2 inches outside diameter (OD) and 1-3/8 inches inside diameter (ID). This standard spoon typically is available in two common lengths, providing either 20-inch or 26-inch longitudinal clearance for obtaining 18-inch or 24-inch long samples, respectively. These split-spoon samplers range in size from 2-inch O.D. to 3-1/2-inch O.D., depending up n manufacturer. The larger sizes are commonly used when a larger volume of material is required.

Rock C ring - A method in which a continuous solid cylindrical sample of rock or compact rock-lik soil is obtained by the use of a double tube core barrel that is equipped with an appropriate diamond-studded drill bit which is advanced with a hydraulic rotary drilling machine.

Wire-Line Coring - As an alternate for conventional coring, this is valuable in deep hole drilling, since this method eliminates trips in and out of the hole with the coring equipment. With this technique the core barrel becomes an integral part of the drill rod string. The drill rod serves as both a coring device and casing.

4.0 RESPONSIBILITIES

Field Operations Leader - Responsible for overall management of field activities and ensuring that the appropriate sampling procedures are being implemented.

Site Ge logist - The site geologist directly oversees the sampling procedures, classifies soil and rock samples, and directs the packaging and shipping of soil samples. Such duties may also be performed by ge technical engineers, field technicians, r other qualified field personnel.

5.0 PROCEDURES

5.1 SUBSURFACE SOIL SAMPLES

Subsurface soil samples are used to characterize subsurface stratigraphy This characterization can indicate the potential for migration of chemical contaminants in the subsurface. In addition, definition of the actual migration of contaminants can be obtained through chemical analysis of the soil samples. Where the remedial activities may include in-situ treatment or the excavation and removal of the contaminated soil, the depth and areal extent of contamination must be known as accurately as possible.

Engineering and physical properties of soil may also be of interest should site construction activities be planned. Soil types, grain size distribution, shear strength, compressibility, permeability, plasticity, unit weight, and moisture content are some of the physical characteristics that may be determined for soil samples.

Penetration tests are also described in this procedure. The tests can be used to estimate various physical and engineering parameters such as relative density, unconfined compressive strength, and consolidation characteristics of soils.

The procedures described here are representative of a larger number of possible drilling and sampling techniques. The choice of techniques is based on a large number of variables such as cost, DQOs, local geology, etc. The final choice of methods must be made with the assistance of drilling subcontractors familiar with the local geologic conditions. Alternative techniques must be based upon the underlying principles of quality assurance implicit in the following procedures.

5.1.1 <u>Equipment</u>

The following equipment is used for subsurface soil sampling and test boring:

- Drilling equipment, provided by subcontractor.
- Split barrel (split spoon) samplers, OD 2 inches, ID 1-3/8 inches, either 20-inch or 26 inch s long. Larger O.D. samplers are available if a larger volume of sample is needed. A common size is 3-inch O.D. (2-1/2-inch I.D.).
- Thin walled tubes (Shelby), O.D. 2 to 5 inches, 18 to 54 inches long.
- Drive weight assembly, 140-lb. (± 2 lb.) weight, driving head and guide permitting fre fall of 30 inches (± 1 inch).
- Drive weight assembly, 300-lb. (± 2 lb.) weight, driving head and guide permitting free fall of 18 inches (± 1 inch).
- Accessory equipment, including labels, logbook, paraffin, and sample jars.

5.1.2 Split Barrel (Split Spoon) Sampling (ASTM D1586-84)

The following method will be used for split barrel sampling:

- Clean out the borehole to the desired sampling depth using equipment that will ensure that the material to be sampled is not disturbed by the operation. In saturated sands and silts, withdraw the drill bit slowly to prevent loosening of the soil around the hole and maintain the water level in the hole at or above groundwater level.

- Side-discharge bits are permissible. A bottom-discharge bit shall not be used. The process of jetting through an open tube sampler and then sampling when the desired depth is reached shall not be permitted. Where casing is used, it may not be driven below the sampling elevation.

- Install the split barrel sampler and sampling rods into the boring to the desired sampling depth. After seating the sampler by means of a single hammer blow, three 6-inch increments shall be marked on the sampling rod so that the progress of the sampler can be monitored.

  The 2-inch OD split barrel sampler shall be driven with blows from a 140-lb. (± 2 lb.) hammer falling 30 inches (± 1 inch) until either a total of 50 blows have been applied during any one of the three 6-inch increments, a total of 100 blows have been applied, there is no observed advance of the sampler for 10 successive hammer blows, or until the sampler has advanced 18 inches without reaching any of the blow count limitation constraints described herein. This process is referred to as the Standard Penetration Test.

- A 300-lb. weight falling 18 inches is sometimes used to drive a 2-1/2-inch or 3-inch O.D. spoon sampler. This procedure is used where dense materials are enountered or when a large volume of sample is required. However, this method does not conform the ASTM specifications.

- Repeat this operation at intervals not greater than 5 feet in homogeneous strata, or as specified in the sampling plan.

  Record the number of blows required to effect each 6 inches of penetration or fraction thereof. The first 6 inches is considered to be seating drive. The sum of the number of blows required for the second and third 6 inches of penetration is termed the penetration resistance, N. If the sampler is driven less than 18 inches, the penetration resistance is that for the last 1 foot penetrated.

- Bring the sampler to the surface and remove both ends and one half of the split barrel s that the soil recovered rests in the remaining half of the barrel. Describe carefully the sample interval, recovery (length), composition, structure, consistency, color, condition, etc., of the recovered soil then put a representative portion of each sample into a jar, without ramming. Jars with samples not taken for chemical analysis shall be sealed with wax, or hermetically sealed (using a teflon cap liner) to prevent evaporation of the s il moisture, if the sample is to be later evaluated for moisture content. Affix labels to the jar and complete Chain-of-Custody and other required sample data forms. Protect samples against extreme temperature changes and breakage by placing them in appropriate cartons stored in a protected area. Pertinent data which shall be noted on the label r written on the jar lid for each sample includes the pr ject number, boring number, sample number, depth interval, blow counts, and date of sampling.

- An addition to the sampler mentioned above is an internal liner, which is split longitudinally and has a thin-wall brass, steel, or paper liner inserted inside, which will preserve the sample. However, since the development of the thin-walled samplers (mentioned below) the split barrel sampler with liner has declined in use.

5.1.3 Thin Walled Tube (Shelby Tube) Sampling (ASTM D1587-83)

When it is desired to take undisturbed samples of soil, thin-walled seamless tube samplers (Shelby tubes) will be used. The following method will be used:

- Clean out the borehole to the sampling depth, being careful to minimize the chance for disturbance of the material to be sampled. In saturated materials, withdraw the drill bit slowly to prevent loosening of the soil around the borehole and maintain the water level in the hole at or above groundwater level.

- The use of bottom discharge bits or jetting through an open-tube sampler to clean out the hole shall not be allowed. Any side discharge bits are permitted.

  A stationary piston-type sampler may be required to limit sample disturbance and aid in retaining the sample. Either the hydraulically operated or control rod activated-type of stationary piston sampler may be used. Prior to inserting the tube sampler in the hole, check to ensure that the sampler head contains a check valve. The check valve is necessary to keep water in the sampling rods from pushing the sample out of the tube sampler during sample withdrawal and to maintain a suction within the tube to help retain the sample.

  To minimize chemical reaction between the sample and the sampling tube, brass tub s may be required, especially if the tube is stored for an extended time prior to testing. While steel tubes coated with shellac are less expensive than brass, they are more reactive, and shall only be used when the sample will be tested within a few days after sampling or if chemical reaction is not anticipated. With the sampling tube resting on the bottom of the hole and the water level in the boring at the groundwater level or above, push the tube into the soil by a continuous and rapid motion, without impacting or twisting. In no case shall the tube be pushed farther than the length provided for the soil sample. Allow about 3 inches in the tube for cuttings and sludge.

- Upon removal of the sampler tube from the hole, measure the length of sample in the tube and also the length penetrated. Remove disturbed material in the upper end of the tube and measure the length of sample again. After removing at least an inch of soil from the lower end and after inserting an impervious disk, seal both ends of the tube with at l ast a 1/2-inch thickness of wax applied in a way that will prevent the wax from entering the sample. Newspaper or other types of filler must be placed in voids at either end of the sampler prior to sealing with wax. Place plastic caps on the ends of the sampler, tape in the caps place, and dip the ends in wax.

- Affix labels to the tubes as required and record sample number, depth, penetration, and recovery length on the label. Mark the same information and "up" direction on the tube with indelible ink, and mark the end of the sample. Complete Chain-of-Custody and other required forms. Do not allow tubes to freeze and store the samples vertically (with the same rientati n they had in the ground, i.e., top of sample is up) in a cool place out of the sun at all times Ship samples protected with suitable resilient packing material to reduce shock, vibration, and disturbance.

Thin-walled undisturbed tube samplers are restricted in their usage by the consistency of the soil to be sampled. Often, very loose and/or wet samples cannot be retrieved by the samplers, and soils with a consistency in excess of very stiff cannot be penetrated by the sampler. Devices such as Denison or Pitcher core samplers can be used to obtain undisturbed samples of stiff soils. Using these devices normally increases sampling costs and therefore their use shall be weighed against the increased cost and the need for an undisturbed sample. In any case, if a sample cannot be obtained with a tube sampler, an attempt shall be made with a split barrel sampler at the same depth so that at least a sample can be obtained for classification purposes.

5.1.4 Continuous Core Soil Samples

The CME continuous sample tube system provides a method of sampling soil continuously during hollow stem augering. The 5-foot sample barrel fits within the lead auger of a hollow auger column. The sampling system can be used with a wide range of I.D. hollow stem augers (from 3-1/4-inch to 8-1/4-inch I.D.). This method has been used to sample many different materials such as glacial drift, hard clays and shales, mine tailigs, etc. This method is particularly used when SPT samples are not requir d and a large volume of material is needed. Also, this method is useful when a visual description of the subsurface lithology is required.

5.2 SURFACE SOIL SAMPLES

F r loosely packed earth or waste pile samples, stainless steel scoops or trowels can be used to collect representative samples. For densely packed soils or deeper soil samples, a hand or power soil auger may be used.

The following methods are to be used:

- Use a soil auger for deep samples (6 to 24 inches) or a scoop or trowel for surface samples. Remove debris, rocks, twigs, and vegetation before collection of soil. Mark the location with a numbered stake if possible and locate sample points on a sketch of the site.
- Use a new or freshly-decontaminated sampler for each sample taken. Attach a label and identification tag. Record all required information in the field logbook and on the sampl log sheet, Chain-of-Custody record, and other required forms.
- Pack and ship accordingly.
- When a representative composited sample is to be prepared (e.g., samples taken from a gridded area or from several different depths), it is best to composite individual samples in the laboratory where they can be more precisely composited on a weight or volume basis. If this is not possible, the individual samples (all of equal volume, i.e., the sample bottles shall be full) shall be placed in a decontaminated stainless steel bucket, mixed thoroughly using a stainless steel spatula or trowel, and a composite sample collected.

5.3 WASTE PILE SAMPLES

The use of stainless steel scoops or trowels to obtain small discrete samples of homogeneous waste piles is usually sufficient for most conditions. Layered (nonhomogeneous) piles require the use of tube samplers to obtain cross-sectional samples.

- Collect small, equal portions of the waste from several points around the pile, penetrating it as far as practical. Use numbered stakes, if possible, to mark the sampling locations and locate sampling points on the site sketch.
- Place the waste sample in a glass container. Attach a label and identification tag. Record all the required information in the field logbook and on the sample log sheet and other required forms.

For layered, nonhomogeneous piles, grain samplers, sampling triers, or waste pile samplers must be used at several representative locations to acquire a cross-section of the pile. The basic steps to obtain each sample are

- Insert a sampler into the pile at a 0- to 45-degree angle from the horizontal to minimize spillage.
- Rotate the sampler once or twice to cut a core of waste material. Rotate the grain sampler inner tube to the open position and then shake the sampler a few times to allow the material to enter the open slits. Move the sampler into position with slots upward (grain sampler closed) and slowly withdraw from the pile.

5.4 ROCK SAMPLING (CORING) (ASTM D2113-83)

Rock coring enables a detailed assessment of borehole conditions to be made, showing precisely all lithologic changes and characteristics. Because coring is an expensive drilling method, it is commonly used for shallow studies of 500 feet or less, or for specific intervals in the drill hole that require detailed logging and/or analyzing. It can, however, proceed for thousands of feet continuously, depending on the size of the drill rig. It yields better quality data than air rotary drilling, although at a substantially reduced drilling rate. Rate of drilling varies widely, depending on the characteristics of lithologies encountered, drilling methods, depth of drilling, and condition of drilling equipment. Av rage output in a 10-hour day ranges from 40 to over 200 feet. Downhole geophysical logging or television camera monitoring is sometimes used to complement the data generated by coring.

Borehole diameter can be drilled to various sizes, depending on the information needed. Standard sizes of core barrels (showing core diameter) and casing are shown in Attachment No. 1.

Core drilling is used when formations are too hard to be sampled by soil sampling methods and a continuous solid sample is desired. Usually, soil samples are used for overburden, and coring begins in sound bedrock. Casing is set into bedrock before coring begins to prevent loose material from entering the borehole, to prevent loss of drilling fluid, and to prevent cross contamination of aquifers.

ATTACHMENT 1

STANDARD SIZES OF CORE BARRELS AND CASING

Coring bit size	Nominal *		Set size *	
	O.D.	I.D.	O.D.	I.D.
RWT	$1\frac{5}{32}$	$\frac{3}{4}$	1.160	.735
EWT	$1\frac{1}{2}$	$\frac{29}{32}$	1.470	.905
EX, EXL, EWG, EWM	$1\frac{1}{2}$	$\frac{13}{16}$	1.470	.845
AWT	$1\frac{7}{8}$	$1\frac{9}{32}$	1.875	1.281
AX, AXL, AWG, AWM	$1\frac{7}{8}$	$1\frac{3}{16}$	1.875	1.185
BWT	$2\frac{3}{8}$	$1\frac{3}{4}$	2.345	1.750
BX, BXL, BWG, BWM	$2\frac{3}{8}$	$1\frac{5}{8}$	2.345	1.655
NWT	3	$2\frac{5}{16}$	2.965	2.313
NX, NXL, NWG, NWM	3	$2\frac{1}{8}$	2.965	2.155
HWT	$3\frac{29}{32}$	$3\frac{3}{16}$	3.889	3.187
HWG	$3\frac{29}{32}$	3	3.889	3.000
$2\frac{3}{4} \times 3\frac{7}{8}$	$3\frac{7}{8}$	$2\frac{3}{4}$	3.840	2.690
$4 \times 5\frac{1}{2}$	$5\frac{1}{2}$	4	5.435	3.970
$6 \times 7\frac{3}{4}$	$7\frac{3}{4}$	6	7.655	5.970
AX Wire line 1/	$1\frac{7}{8}$	1	1.875	1.000
BX Wire line 1/	$2\frac{3}{8}$	$1\frac{7}{16}$	2.345	1.437
NX Wire line 1/	3	$1\frac{15}{16}$	2.965	1.937

* All dimensions are in inches; to convert to millimeters, multiply by 25.4.
1/ Wire line dimensions and designations may vary according to manufacturer

ATTACHMENT 1
PAGE TWO

Size Designations			Casing coupling					Approximate core diameter	
Casing, Casing coupling; Casing bits, Core barrel bits	Rod, Rod couplings	Casing O.D., inches	O.D., inches	I.D., inches	Casing bit, O.D., inches	Core barrel bit O.D., inches *	Drill rod O.D., inches	Normal, inches	Thinwall, inches
RX	RW	1.437	1.437	1.188	1.485	1.160	1.094	—	.735
EX	E	1.812	1.812	1.500	1.875	1.470	1.313	.845	.905
AX	A	2.250	2.250	1.906	2.345	1.875	1.625	1.185	1.281
BX	B	2.875	2.875	2.375	2.965	2.345	1.906	1.655	1.750
NX	N	3.500	3.500	3.000	3.615	2.965	2.375	2.155	2.313
HX	HW	4.500	4.500	3.938	4.625	3.890	3.500	3.000	3.187
RW	RW	1.437	Flush joint	No coupling	1.485	1.160	1.094	—	.735
EW	EW	1.812			1.875	1.470	1.375	.845	.905
AW	AW	2.250			2.345	1.875	1.750	1.185	1.281
BW	BW	2.875			2.965	2.345	2.125	1.655	1.750
NW	NW	3.500			3.615	2.965	2.625	2.155	2.313
HW	HW	4.500			4.625	3.890	3.500	3.000	3.187
PW	—	5.500			5.650	—	—	—	—
SW	—	6.625			6.790	—	—	—	—
UW	—	7.625			7.800	—	—	—	—
ZW	—	8.625			8.810	—	—	—	—
—	AX 1/	—	—	—	—	1.875	1.750	1.000	—
—	BX 1/	—	—	—	—	2.345	2.250	1.437	—
—	NX 1/	—	—	—	—	2.965	2.813	1.937	—

* For hole diameter approximation, assume $\frac{1}{32}$ inch larger than core barrel bit.

1/ Wire line size designation, drill rod only, serves as both casing and drill rod. Wire line core bit, and core diameters vary slightly according to manufacturer.

NOMINAL DIMENSIONS FOR DRILL CASINGS AND ACCESSORIES. (DIAMOND CORE DRILL MANUFACTURERS ASSOCIATION). 288-D-2889.

Drilling through bedrock is initiated by using a diamond-tipped core bit threaded to a drill rod (outer core barrel) with a rate of drilling determined by the downward pressure, rotation speed of drill rods, drilling fluid pressure in the borehole, and the characteristics of the rock (mineralogy, cementation, weathering).

5.4.1 Diamond Core Drilling

A penetration of typically less than 6 inches per 50 blows using a 140-lb. hammer dropping 30 inches with a 2-inch split spoon sampler shall be considered an indication that soil sampling methods may not be applicable and that coring may be necessary to obtain samples.

Wh n formations are encountered that are too hard to be sampled by soil sampling methods, the following diamond core drilling procedure may be used.

- Firmly seat a casing into the bedrock or the hard material to prevent loose materials from entering the hole and to prevent the loss of drilling fluid return. Level the surface of the rock or hard material when necessary by the use of a fishtail or other bits. If the drill hole can be retained open without the casing and if cross contamination of aquifers in the unconsolidated materials is unlikely, it may be omitted.

- Begin the core drilling using a double-tube swivel-core barrel of the desired size. Aft r drilling no more than 10 feet (3 m), remove the core barrel from the hole, and take out the core. If the core blocks the flow of the drilling fluid during drilling, remove the core barrel immediately. In soft materials, a large starting size may be specified for the coring tools; where local experience indicates satisfactory core recovery or where hard, sound materials are anticipated, a smaller size or the single-tube type may be specified and longer runs may be drilled. NX/NW size coring equpment is the most commonly used size.

- When soft materials are encountered that produce less than 50 percent recovery, stop the core drilling. If soil samples are desired, secure such samples in accordance with the procedures described in ASTM Method D 1586 (Split Barrel Sampling) or in Method D 1587 (Thin-Walled Tube Sampling) for Sampling of Soils (see Section 5.1.1 and 5.1.2). Resume diamond core drilling when refusal materials are again encountered.

  Since rock structures and the occurrence of seams, fissures, cavities, and broken areas are among the most important items to be detected and described, take special care to btain and record these features. If such broken zones or cavities prevent further advance of the boring, one of the following three steps shall be taken: (1) cement the hole; (2) ream and case; or (3) case and advance with the next smaller size core barrel, as the conditions warrant.

  In soft, seamy, or otherwise unsound rock, where core recovery may be difficult, M-design core barrels may be used. In hard, sound rock where a high percentage of core recovery is anticipated, the single-tube core barrel may be employed.

5.4.2 Rock Sample Preparation and Documentation

Onc the rock coring has been completed and the core recovered, the rock core shall be carefully rem v d fr m the barrel, placed in a c re tray (previously labeled "top" and "bottom" to av id confusi n), classified, and measured f r percentage of recovery as well as the rock quality designation (RQD). Each core shall be described, classified, and logged using a uniform system as presented in Procedure GH-1.5. If moisture c:-tent will be determined or if it is desirable to prevent drying (e g .

to prevent shrinkage of clay formations) or oxidation of the core, the core shall be wrapped in plastic sleeves immediately after logging. Each plastic sleeve shall be labeled with indelible ink The boring number, run number, and the footage represented in each sleeve shall be included, as well as the top and bottom of the core run.

After sampling, rock cores shall be placed in the sequence of recovery in well-constructed wooden boxes provided by the drilling contractor. Rock cores from two different borings shall not be placed in the same core box unless accepted by the Site Geologist. The core boxes shall be constructed to accommodate at least 20 linear feet of core in rows of approximately 5 feet each and shall be constructed with hinged tops secured with screws, and a latch (usually a hook and eye) to keep the top securely fastened down. Wood partitions shall be placed at the end of each core run and between rows. The depth from the surface of the boring to the top and bottom of the drill run and run number shall be marked on the wooden partitions with indelible ink. A wooden partition (wooden block) shall be placed at the end of each run with the depth of the bottom of the run written on the block. These blocks will serve to separate successive core runs and indicate depth intervals for each run. The order of placing cores shall be the same in all core boxes. Rock core shall be placed in the box so that, when the box is open, with the inside of the lid facing the observer,the top of the cored interval contained within the box is in the upper left corner of the box,and the bottom of the cored interval is in the lower right corner of the box (see Attachment 2). The top and bottom of each core obtained and its true depth shall be clearly and permanently marked on each box. The width of each row must be compatible with the core diameter to prevent lateral movem nt of the core in the box. Similarly, an empty space in a row shall be filled with an appropriate filler material or spacers to prevent longitudinal movement of the core in the box.

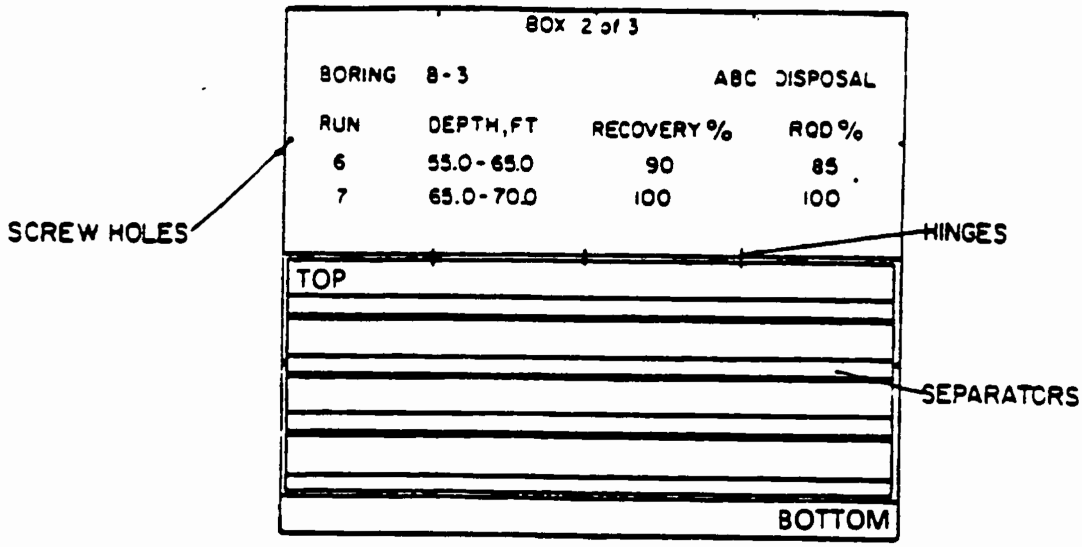
The inside and outside of the core-box lid shall be marked by indelible ink to show all pertinent data on the box's contents. At a minimum, the following information shall be included:

- Project name
- Project number
- Boring number
- Run numbers
- Footage (depths)
- Recovery
- RQD (%)
- Box number and total number of boxes for that boring (Example: Box 5 of 7).

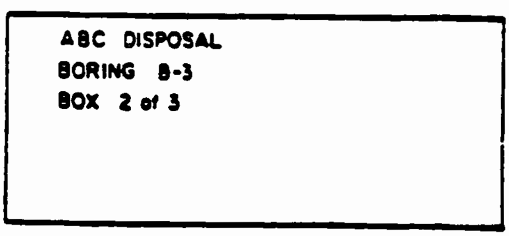
For easy retrieval when core boxes are stacked, the sides and ends of the box shall also be labeled and include project number, boring number, top and bottom depths of core and box number. Attachment No. 2 illustrates a typical rock core box.

Prior to final closing of the core box, a photograph of the recovered core and the labeling on the inside c ver shall be taken. If moisture content is not critical, the core shall be wetted and wiped clean for the photograph. (This will help to show true colors and bedding features in the cores).

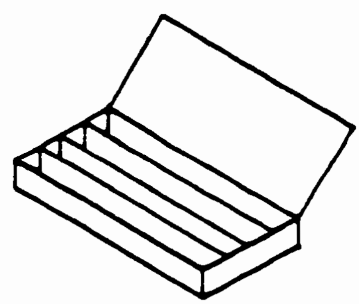
ATTACHMENT 2

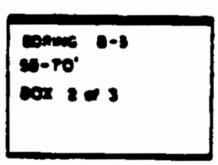


CORE BOX (OBLIQUE VIEW)



CORE BOX (TOP VIEW)





CORE BOX (END VIEW)

TYPICAL ROCK CORE BOX

NOT TO SCALE

NUS CORPORATION
A Halliburton Company

6.0 REFERENCES

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7.0 RECORDS

None.

STANDARD OPERATING PROCEDURES

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1.0 PURPOSE

The purpose of this procedure is to describe th - nethods, the sequence of operations and th equipment necessary to perform soil and rock borings.

2.0 SCOPE

This guideline addresses most of the accepted and standard drilling techniques, their benefits and drawbacks. It should be used generally to determine what type of drilling techniques would be most successful depending on site-specific geologic conditions and the type of sampling required.

3.0 GLOSSARY

Boulders - Rounded, semi-rounded or naturally angular particles of rock larger than 12 inches in diameter.

Clay - Fine grained soil or portions of soil having certain physical properties, composition and texture. Clay exhibits plastic properties within a range of water contents and exhibits considerable strength when air dried. Clay consists usually of fragments of hydrous aluminum or magnesium silicate minerals, and it consists predominantly of grains with diameters of less than 0.005 mm.

Cobbles - Rounded, semi-rounded or naturally angular particles of rock between 3 inches and 12 inches in diameter.

Gravel - Rounded or semirounded particles of rock that will pass a 3 inch sieve (7.62 cm) and be retained on a No. 4 U.S. standard sieve (4.76 mm). Coarse gravel is larger than 3/4-inches, while fine gravel is finer than 3/4-inches.

Stone - Crushed or naturally angular particles of rock that will pass a 3 inch sieve (7.62 cm) and be retained on a No. 4 U.S. standard sieve (4.76 mm).

R ck - Any consolidated or coherent and relatively hard, naturally formed mass of mineral matter.

Sand - Particles of rock that will pass a No. 4 U.S. standard sieve (4.76 mm) and be retained on a No. 200 U.S. standard sieve (0.074 mm). Coarse sand is larger than a No. 10 sieve, and fine sand is finer than a No. 40 sieve (0.42 mm).

Silt - Material passing the No. 200 U.S. standard sieve (0.074 mm) that is nonplastic or very slightly plastic and that exhibits little or no strength when air dried.

S il - Sediments or other unconsolidated accumulations of solid particles that are produced by the physical and chemical disintegration of rock and that may contain organic matter.

Undisturbed Sample - A soil sample that has been obtained by methods in which every precaution has been taken to minimize disturbance to the sample.

Water Table - A surface in an aquifer where groundwater pressure is equal to atmospheric pressure.

4.0 RESPONSIBILITIES

Site Manager - In consultation with the project geologist, responsible for evaluating the drilling requirements for the site and specifying drilling techniques that will be successful given the study objectives and geologic conditions at the site. He should also determine the disposal methods for products generated by drilling, such as drill cuttings and well development water, as well as any specialized supplies or logistical support required for the drilling operations.

Site Geologist/Rig Geologist - Responsible for insuring that standard and approved drilling procedures are followed. The geologist will generate a detailed boring log for each test hole. This log shall include a description of materials, samples, method of sampling, blow counts, and other pertinent drilling and testing information that may be obtained during drilling (see Attachment A of Procedure GH-1.7). Often this position for inspecting the drilling operations may be filled by other geotechnical personnel, such as soils and foundation engineers, civil engineers, etc.

Determination of the exact location for borings is the responsibility of the site geologist. The final location for drilling must be properly documented on the boring log. The general area in which the borings are to be located will be shown on a site map included in the Work Plan.

Field Op rations Leader - Responsible for overall supervision and scheduling of drilling activities.

Drilling Subcontractor - Responsible for obtaining all drilling permits and clearances, and supplying all services (including labor), equipment and material required to perform the drilling, testing, and w ll installation program, as well as maintenance and quality control of such required equipment except as stated in signed and approved subcontracts.

The driller must report any major technical or analytical problems encountered in the field to the Field Operations Leader within 24 hours, and must provide advance written notification for any changes in field procedures describing and justifying such changes. No such changes shall be made unless requested and authorized in writing by the Field Operations Leader.

The drilling subcontractor will be responsible for following decontamination procedures specified in the Work Plan. Upon completion of the work, the Drilling Subcontractor will be responsible for demobilizing all equipment, cleaning up any materials deposited on site during drilling operations, and properly backfilling any open borings.

5.0 PROCEDURES

5.1 GENERAL

The purpose of drilling boreholes is:

- To determine the type, thickness, and certain physical and chemical properties of the soil, water and rock strata which underlie the site, and
- To install monitoring wells or piezometers.

All drilling and sampling equipment will be cleaned using appropriate decontamination procedures (see Procedure GH-1.6 and SF-2.3) between samples and borings. Unless otherwise specified, it is generally advisable to drill borings at "clean" locations first, and at the most contaminated locations last, to reduce the risk of spreading contamination between locations. All borings must be logged by the rig geologist as they proceed (see Procedur GH-1.5) unless the FSAP specifically states that logging is not required. Situations where logging would not be required would include installation of multiple well points within a small area, or a "second attempt" boring adjacent to a boring that could not be continued through resistant material. In the latter case, the boring log can be resumed 5 feet above the depth at which the initial boring was abandoned, although the rig geologist should still confirm that the stratigraphy at the redrilled location conforms essentially with that encountered at the original location. If significant differences are seen, each hole should be logged separately

5.2 DRILLING METHODS

The selected drilling methods described below apply to drilling in subsurface materials, including, but not limited to, sand, gravel, clay, silt, cobbles, boulders, rock and man-made fill. Drilling methods should be selected after studying the site geology and terrain, purpose of drilling, waste conditions at the site, and the overall subsurface investigation program proposed for the site. The full range of different drilling methods applicable to the proposed program should be identified with final selection based on relative cost, availability, time constraints, and how well each method meets the sampling and testing requirements of the individual drilling program.

5.2.1 Continuous-Flight Hollow-Stem Auger Drilling

This method of drilling consists of screwing augers with a hollow stem into the ground. Cuttings are brought to the surface by the rotating action of the auger. This method is relatively quick and inexpensive. Advantages of this type of drilling include:

- Samples can be obtained without pulling the augers out of the hole. However, this is a poor method for obtaining grab samples from thin, discrete formations because of mixing of soils which occurs as the material is brought to the surface. Sampling of such formations will require the use of split-barrel or thin-wall tube samplers advanced through the hollow core of the auger.

- No drilling fluids are required.

- A well can be installed inside the auger stem and backfilled as the augers are withdrawn.

Disadvantages and limitations of this method of drilling include:

- Augering can only be done in unconsolidated materials.

- The inside diameter of hollow stem augers used for well installation should be at least f ur inches greater than the well casing. Use of such large diameter hollow stem augers is more expensive than the use of small diameter augers in boreholes not used for well installation. Furthermore, the density of unconsolidated materials and depths become more of a limiting factor. More friction is produced with the larger diameter auger and subsequently greater torque is needed to advance the boring.

  The maximum effective depth for drilling is 150 feet or less, depending on site conditions and the size of augers used.

  In augering through clean sand formations below the water table, the sand will tend to flow into the hollow stem when the plug is removed for soil sampling or well installation. If the condition of "running" or "flowing" sands is persistent at a site, an alternative method f drilling is recommended, in particular for wells or boreholes deeper than 25 feet. Hollow stem auger drilling is the preferred method f drilling. Most alternative methods require the introduction of water or mud downhole (air rotary is the exception) to maintain the open borehole. With these other methods great care must be taken to ensure that the method does not interfere with the collection of a representative sample which is the object of the construction. With this in mind, the preferred order of choice of drilling method after hollow stem augering (HSA) is:

- Cable tool
- Casing drive (air)
- Air rotary
- Mud rotary
- Drive and wash
- Jetting

However, the use of any method will also depend on efficiency and cost-effectiveness. In many cases, mud rotary is the only feasible alternative to hollow stem augering. Thus, mud rotary drilling is generally acceptable as a first substitute for HSA.

The procedures for sampling soils through holes drilled by hollow-stem auger shall conform with the applicable ASTM Standards: D1587-83 and D1586-84. The hollow stem auger may be advanced by any power-operated drilling machine having sufficient torque and ram range to rotate and force the auger to the desired depth. The machine must, however, be equipped with the accessory equipment needed to perform required sampling, or rock coring.

Wh n taking soil samples for chemical analysis, the hollow-stem auger shall be plugged until the desir d sampling depth is reached. Samples can be taken using split-spoon or thin wall tube samplers driven into the formation in advance of the auger (see Procedure GH-1.3). If the sample is to be taken at a relatively deep point, the auger may be advanced without a plug to within five feet of the sample depth. Then clean out the auger stem, insert a plug and continue to the sampling depth. The plug is then removed and samples taken as specified by the rig geologist. Samples should be taken according to the specifications of the sampling plan. Any required sampling shall be performed by r tation, pressing, or driving in accordance with the standard or approved method governing use of the particular sampling tool. The sequence shall be repeated for each sample desired.

The hollow-stem auger may be used without the plug when boring for geotechnical examination r f r well installation.

Wh n drilling below the water table, specially-designed plugs which allow passage of formation water but not solid material shall be used (see Reference 1 of this guideline). This method also prevents blow back and plugging of the auger when the plug is removed for sampling.

Alternately, it may be necessary to keep the hollow stem full of water, at least to the level of the wat r table, to prevent blowback and plugging of the auger. If water is added to the hole, it must be sampled and analyzed to determine if it is free from contaminants prior to use. In addition, the amount of water introduced, the amount recovered upon attainment of depth, and the amount of water extracted during well development must be carefully logged in order to ensure that a representative sample of the formation water can be obtained. Well development should occur as soon after well completion as practicable (see GH-1.7 for Well Development Procedures). If gravelly or hard material is encountered which prevents advancing the auger to the desired depth, augering should be halted and either driven casing or hydraulic rotary methods should be attempted. If the depth to the bedrock/soil interface and bedr ck lithology must be determined, then a 5-f ot c nfirmatory core run should be conducted (see Secti n 5.2.9).

At the option of the Field Operations Leader, when resistant materials prevent the advancement of the auger, a new boring can be attempted. The original boring must be properly backfilled and the new boring started a short distance away at a location determined by the site geologist. If multiple water bearing strata were encountered, the original boring must be grouted. In some formations it may be prudent to also grout borings which only penetrate the water table aquifer, since loose soil backfill in the boring would still provide a preferred pathway for surface liquids to reach the water table.

5.2.2 Continuous-Flight Solid-Stem Auger Drilling

This method is similar to hollow-stem augering. Practical application of this method is severely restricted as compared with hollow stem augers. Split barrel (split-spoon) sampling cannot be done without pulling the augers which may allow the hole to collapse. The method is therefore very time consuming and is not cost effective. Also, augers would have to be withdrawn before installing a monitoring well, which again, may allow the hole to collapse. Furthermore, geologic logging by examining the soils brought to the surface is unreliable as in the case of the hollow stem auger, and depth to water may be difficult to determine while drilling.

There would be very few situations where use of a solid stem auger would be preferable to other drilling methods. The only practical applications of this method would be to drill boreholes for well installation where no lithologic information is desired and the soils are such that the borehole can be expected to remain open after the augers are withdrawn. Alternatively, the technique can be used to find depth to bedrock in an area when no other information is required from drilling.

5.2.3 Rotary Drilling

Direct rotary drilling includes air-rotary and fluid-rotary drilling. Air-rotary drilling is a method of drilling where the drill rig simultaneously turns and exerts a downward pressure on the drilling rods and bit while circulating compressed air down the inside of the drill rods, around the bit, and out th annulus of the borehole. Air circulation serves to both cool the bit and remove the cuttings from the borehole. Advantages of this method include:

- The drilling rate is high (even in rock).
- The cost per foot of drilling is relatively low.
- Air rotary rigs are common in most areas.
- No drilling fluid is required (except when water is inje d to keep down dust).
- The borehole diameter is large, to allow room for prop well installation procedures.

Disadvantages to using this method include:

- Formations must be logged from the cuttings that are blown to the surface and thus the depths of materials logged are approximate.
- Air blown into the formation during drilling may "bind" the formation and impede w ll development and natural groundwater flow.
- In-situ samples cannot be taken, unless the hole is cased.
- Casing must generally be used in unconsolidated materials.
- Air rotary drill rigs are large and heavy.

A variation of the typical air-rotary drill bit is a down hole hammer which hammers the drill bit down as it drills. This makes drilling in hard rock faster. Air-rotary drills can also be adapted to use for rock coring although they are generally slower than other types of core drills. A major application of the air-rotary drilling method would be to drill holes in rock for well installation.

Fluid-Rotary drilling operates in a similar manner to air rotary drilling except that a drilling fluid ("mud") or clean water is used in place of air to cool the drill bit and remove cuttings. There are a variety of fluids that can be used with this drilling method, including bentonite slurry and synthetic slurries. If a drilling fluid other than water/cuttings is used, it must be a natural clay (i.e., bentonite) and a "background" sample of the fluid should be taken for analysis of possible organic or inorganic contaminants.

Advantages to the fluid-rotary drilling method include:

- The ability to drill in many types of formations.
- Relatively quick and inexpensive.
- Split barrel (split-spoon) or thin-wall tube samples can be obtained without removing drill rods if the appropriate size drill rods and bits (i.e., fish-tail or drag bit) are used.
- In some borings temporary casing may not be needed as the drilling fluids may keep the borehole open.
- Drill rigs are readily available in most areas.

Disadvantages to this method include:

- Formation logging is not as accurate as with hollow stem auger method if split barrel (split-spoon) samples are not taken (i.e., the depths of materials logged from cuttings deliver d to the surface are approximate).
- Drilling fluids reduce permeability of the formation adjacent to the boring to some degr e, and require more extensive well development than "dry" techniques (augering, air-rotary).

  No information on depth to water is obtainable while drilling.
- Fluids are needed for drilling, and there is some question about the effects of the drilling fluids on water samples obtained. For this reason as well, extensive well development may be required.
- In very porous materials (i.e., rubble fill, boulders, coarse gravel) drilling fluids may be continuously lost into the formation. This will require either constant replenishment of the drilling fluid, or the use of casing through this formation.
- Drill rigs are large and heavy, and must be supported with supplied water.
- Ground water samples can be potentially diluted with drilling fluid.

The procedures for performing direct rotary soil investigations and sampling shall c nform with the applicable ASTM standards: D2113-83, D1587-83, and D1586-84.

For air or fluid-rotary drilling, the rotary drill may be advanced to the desired depth by any power-operated drilling machine having sufficient torque and ram range to rotate and force the bit to the desired depth. The drilling machine must, however, be equipped with any accessory equipment needed to perform required sampling, or coring. Prior to sampling, any settled drill cuttings in the borehole must be removed.

Soil samples shall be taken as specified by the Work Plan or more frequently if requested by the field geologist. Any required sampling shall be performed by rotation, pressing, or driving in accordance with the standard or approved method governing use of the particular sampling tool.

When field conditions prevent the advancement of the hole to the desired depth, a new boring may be drilled at the request of the Field Operations Leader. The original boring shall be backfilled using methods and materials appropriate for the given site and a new boring started a short distance away at a location determined by the site geologist.

5.2.4 Reverse Circulation Rotary Drilling

The common reverse-circulation rig is a water or mud rotary rig with a large diameter drill pipe which circulates the drilling water down the annulus and up the inside of the drill pipe (reverse flow direction from direct mud rotary). This type of rig is used for the construction of large-capacity production water wells and is not suited for small, water-quality sampling wells because of the use of drilling muds and the large diameter hole which is created. A few special reverse-circulation rotary rigs are made with double-wall drill pipe. The drilling water or air is circulated down the annulus between the drill pipes and up inside the inner pipe.

Advantages of the latter method include:

- The formation water is not contaminated by the drilling water.
- Formation samples can be obtained, from known depths.
- When drilling with air, immediate information is available regarding the water-bearing properties of formations penetrated.
- Collapsing of the hole in unconsolidated formations is not as great a problem as when drilling with the normal air rotary rig.

Disadvantages include:

- Double-wall, reverse-circulation drill rigs are very rare and expensive to operate.
- Placing cement grout around the outside of the well casing above a well screen often is difficult, especially when the screen and casing are placed down through the inner drill pipe before the drill pipe is pulled out.

5.2.5 Drill-through Casing Driver

The driven-casing method consists of alternately driving casing (fitted with a sharp, hardened casing shoe) into the ground using a hammer lifted and dropped by the drill rig or an air hammer and cleaning out the casing using a rotary chopping bit and air or water to flush out the materials. The casing is driv n down in stag s (usually 5 f et per stage). A c ntinuous record is kept of the bl ws per foot in driving the casing (see Procedure GH-1.5). The casing is normally advanced by a 300-pound hammer falling freely through a height of 30-inches. Simultaneous washing and driving of the casing is not recommended. If this procedure is used, the elevations between which water is used in driving the casing should be recorded.

The driven casing method is used in unconsolidated formations only. When the boring is to be used for later well installation, the driven casing used should be at least four inches larger in diameter than the well casing to be installed. Advantages to this method of drilling include:

- Split barrel (split-spoon) sampling can be conducted while drilling.
- Well installation is easily accomplished.
- Drill rigs used are relatively small and mobile.
- The use of casing minimizes flow into the hole from upper water-bearing layers; therefore multiple aquifers can be penetrated and sampled for rough field determinations of some water quality parameters.

Some f the disadvantages include:

- This method can only be used in unconsolidated formations.
- The method is slower than other methods (average drilling progress is 30 to 50 feet per day).
- Maximum depth of the borehole varies with the size of the drill rig and casing diameter used, and the nature of the formations drilled.
- The cost per hour or per foot of drilling may be substantially higher than other drilling methods.
- It is difficult and time consuming to pull back the casing if it has been driven very deep (deeper than 50 feet in many formations).

5.2.6 Cable Tool Drilling

A cable tool rig uses a heavy, solid-steel, chisel-type drill bit ("tool") suspended on a steel cable, which when raised and dropped chisels or pounds a hole through the soils and rock. Drilling progress may b expedited by the use of "slip-jars" which serve as a cable-activated down hole percussion device to hammer the bit ahead.

When drilling through the unsaturated zone, some water must be added to the hole. The cuttings are suspended in the water and then bailed out periodically. Below the water table, after sufficient ground water enters the borehole to replace the water removed by bailing, no further water need be added.

When soft caving formations are encountered, it is usually necessary to drive casing as the hole is advanced to prevent collapse of the hole. Often the drilling can be only a few feet below the bottom of the casing. Because the drill bit is lowered through the casing, the hole created by th bit is smaller than the casing. Therefore, the casing (with a sharp, hardened casing shoe on the bottom) must be driven int the hole (see Section 5.2.5 of this guideline).

Advantages of the cable-tool method include the following:

- Information regarding water-bearing zones is readily available during the drilling Even relative permeabilities and rough water quality data from different zones penetrated can be obtained by skille operators.

- The cable-tool rig ca erate satisfactorily in all formations, but is best suited for caving, boulder, c. or coa avel type formations (e.g., glacial till) or formations with large cavities abo ne wat le (such as limestones).

- When casing is used, casing seals formation water out of the hole, preventing down-hole contamination and allowing sampling of deeper aquifers for field-measurable water quality parameters.

  Split barrel (split spoon) or thin-wall tube samples can be collected through the casing.

Disadvantages include:

  Drilling is slow compared with rotary rigs.

- The necessity of driving the casing in unconsolidated formations requires that the casing be pulled back if exposure of selected water-bearing zones is desired. This process complicates the well completion process and often increases costs. There is also a chance that the casing may become stuck in the hole.

- The relatively large diameters required (minimum of 4-inch casing) plus the cost of steel casing result in higher costs compared to rotary drilling methods where casing is not required, such as use of a hollow stem auger.

- Cable-tool rigs have largely been replaced by rotary rigs. In some parts of the U.S., availability may be difficult.

5.2.7 Jet Drilling (Washing)

Jet drilling, which should be used only for piezometer or vadose zone sampler installation, consists of pumping water or drilling mud down through a small diameter (1/2 to 2-inch) standard pipe (steel or PVC). The pipe may be fitted with a chisel bit or a special jetting screen. Formation materials dislodged by the bit and jetting action of the water are brought to the surface through the annulus around the pipe. As the pipe is jetted deeper, additional lengths of pipe may be added at the surface.

Jet percussion is a variation of the jetting method, in which the casing is driven with a drive weight. Normally, this method is used to place 2-inch diameter casing in shallow, unconsolidated sand formations but has been used to install 3- to 4-inch diameter casings to 200 feet.

Jetting is acceptable in very soft formations, usually for shallow sampling, and when introduction of drilling water to the formation is acceptable Such conditions would occur during rough stratigraphic investigation or installation of piezometers for water level measurement. Advantages of this method include:

- Jetting is fast and inexpensive.
- Because of the small amount of equipment required, jetting can be accomplished in locations where access by a normal drilling rig would be very difficult. For example, it would be possible to jet down a well point in the center of a lagoon at a fraction of the cost of using a drill rig.
- Jetting numerous well points just into a shallow water table is an inexpensive method for determining the water table contours, hence flow direction.

Disadvantages include the following:

- A large amount of foreign water or drilling mud is introduced above and into the formation to be sampled.
- Jetting is usually done in very soft formations which are subject to caving. Because of this caving, it is often not possible to place a grout seal above the screen to assure that water in the well is only from the screened interval.
- The diameter of the casing is usually limited to 2 inches; therefore, samples must be obtained by methods applicable to small diameter casings.
- Jetting is only possible in very soft formations that do not contain boulders or coarse gravel, and the depth limitation is shallow (about 30 feet without jet percussion equipment).
- Large quantities of water are often needed.

5.2.8 Drilling with a Hand Auger

This method is applicable wherever the formation, total depth of sampling, and the site and groundwater conditions are such as to allow hand auger drilling. Hand augering can als be considered at locations where drill rig access is not possible. All hand auger borings will be performed according to ASTM D1452-80.

Samples should be taken continuously unless otherwise specified by the Work Plan. Any required sampling is performed by rotation, pressing, or driving in accordance with the standard or approved method governing use of the particular sampling tool. Typical equipment used for sampling and advancing shallow "hand auger" holes are Iwan samplers (which are rotated) or post hole diggers (which are operated like tongs). This technique is slow but effective where larger pieces of equipment do not have access and where very shallow holes are desired (less than 5 feet). Surficial soils must be composed of relatively soft and non-cemented formations to allow penetration by the auger.

5.2.9 Rock Drilling and Coring

When soil borings cannot be continued using augers or rotary methods due to the hardness of the soil or when rock or large boulders are encountered, drilling and sampling can be performed using a diamond bit corer in accordance with ASTM D2113.

Drilling is done by rotating and applying downward pressure to the drill rods and drill bit. The drill bit is a circular, hollow, diamond studded bit attached to the outer core barrel in a double tube core barrel. The use of single tube core barrels is not recommended, as the rotation of the barrel erodes the sample and limits its use for detailed geological evaluation. Water or air is circulated down through the drill rods and annular space between the core barrel tubes to cool the bit and remove the cuttings. The bit cuts a core out of the rock which rises into an inner barrel mounted inside the outer barrel. The inner core barrel and rock core are removed by lowering a wire line with a coupling into the drill rods, latching onto the inner barrel and withdrawing the inner barrel. A less efficient variation to this method utilizes a core barrel that cannot be removed without pulling all of the drill rods. This variation is practical only if less than 50 feet of core is required.

Core borings are made through the casing used for the soil borings. The casing must be driven and sealed into the rock formation to prevent seepage from the overburden into the hole to be cored (see S ction 5.3 of this guideline). A double-tube core barrel with a diamond bit and reaming shell or equivalent should be used to recover rock cores of a size specified in the Work Plan. The most common core barrel diameters are listed in Attachment A. Soft or decomposed rock should be sampled with a driven split-barrel whenever possible or cored with a Denison or Pitcher sampler.

When coring rock, including shale and claystone, the speed of the drill and the drilling pressur , amount and pressure of water, and length of run can be varied to give the maximum recovery from the rock being drilled. Should any rock formation be so soft or broken that the pieces continually fall into the hole, causing unsatisfactory coring, the hole should be reamed and a flush joint casing installed to a point below the broken formation. The size of the flush joint casing must permit s curing the core size specified. When soft or broken rock is anticipated, the length of core runs should be reduced to less than 5 feet to avoid core loss and minimize core disturbance.

Advantages of core drilling include:

- Undisturbed rock cores can be recovered for examination and/or testing.
- In formations in which the cored hole will remain open without casing, water from the rock fractures may be recovered from the well without the installation of a well screen and gravel pack.
- Formation logging is extremely accurate.
- Drill rigs are relatively small and mobile.

Disadvantages include:

- Water or air is needed for drilling.
- Coring is slower than rotary drilling (and more expensive).

- Depth to water cannot accurately be determined if water is used for drilling.

  The size of the borehole is limited.

This drilling method is useful if accurate determinations of rock lithology are desired or if open wells are to be installed into bedrock. To install larger diameter wells in coreholes, the hole must be reamed out to the proper size after boring, using air or mud rotary drilling methods

5.2.10 Drilling & Support Vehicles.

In addition to the drilling method required to accomplish the objectives of the field program, the type of vehicle carrying the drill rig and/or support equipment, and its suitability for the site terrain, will often be an additional deciding factor in planning the drilling program. The types of vehicles available are extensive, and depend upon the particular drilling subcontractor's fleet. Most large drilling subcontractors will have a wide variety of vehicle and drill types suited for most drilling assignments in their particular region, while smaller drilling subcontractors will usually have a fleet of much more limited diversity. The weight size, and means of locomotion (tires, tracks, etc.) of the drill rig must be selected to be compatible with the site terrain, to assure adequate mobility between borehole locations. Such considerations also apply to necessary support vehicles used to transport water and/or drilling materials to the drill rigs at the borehole locations. When the drill rigs or support vehicles do not have adequate mobility to easily traverse the site, provisions must be made for assisting equipment, such as bulldozers, winches, timber planking, etc., to maintain adequate progress during the drilling program.

Some of the typical vehicles which are usually available for drill rigs and support equipment are:

- Totally portable drilling/sampling equipment, where all necessary components (tripods, samplers, hammers, catheads, etc.) may be hand-carried to the borehole site. Drilling/sampling methods used with such equipment include:

  - Hand augers and lightweight motorized augers
  - Retractable plug samplers-driven by hand (hammer)
  - Motorized cathead - a lightweight aluminum tripod with a small gas-engine cathead mounted on one leg, used to install small diameter cased borings. This rig is sometimes called a "monkey on a stick."

- Skid-mounted drilling equipment containing a rotary drill or engine-driven cathead (to lift hammers and drill string), a pump, and a dismounted tripod. The skid is pushed, dragged, or winched (using the cathead drum) between boring locations.

  Small truck-mounted drilling equipment uses a jeep, stake body or other light truck (4 to 6 wheels), upon which are mounted the drill and/or a cathead, a pump, and a tripod or small drilling derrick. On some rigs the drill and/or a cathead are driven by a power take-off from the truck, instead of by a separate engine.

- Track-mounted drilling equipment is similar to truck-mounted rigs, except that the vehicle used has wide bulldozer tracks for traversing soft ground. Sometimes a continuous-track "all terrain vehicle" is also modified for this purpose. Some types of tracked drill rigs are called "bombardier" or "weasel" rigs.

- Heavy truck-mounted drilling equipment is mounted on tandem or dual tandem trucks to transport the drill, derrick, winches, and pumps or compressors. The drill may be provided with a separate engine or may use a power take-off from the truck engine. Large augers, hydraulic rotary and reverse circulation rotary drilling equipment are usually mounted on such heavy duty trucks. For soft-ground sites, the drilling equipment is sometimes mounted on and off the road vehicle having low pressure, very wide diameter tires and capable of floating; these vehicles are called "swamp buggy" rigs.

- Marine drilling equipment is mounted on various floating equipment for drilling borings in lakes, estuaries and other bodies of water. The floating equipment varies, and is often manufactured or customized by the drilling subcontractor to suit specific drilling requirements. Typically, the range of flotation vehicles includes:

  - Barrel float rigs - a drill rig mounted on a timber platform buoyed by empty 55-gallc drums or similar flotation units.

  - Barge-mounted drill rigs.

  - Jack-up platforms - drilling equipment mounted on a floating platform having retractable legs to support the unit on the sea or lake bed when the platform is jacked up out of the water.

  - Drill ships - for deep ocean drilling.

In addition to the mobility for the drilling equipment, similar consideration must be given for equipment to support the drilling operations. Such vehicles or floating equipment are needed to transport drill water, drilling supplies and equipment, samples, drilling personnel, etc. to and/or from various boring locations.

5.2.11 Equipment Sizes

In planning subsurface exploration programs, care must be taken in specifying the various drilling c mponents, so that they will fit properly in the boring or well.

For drilling open boreholes using rotary drilling equipment, tri-cone drill bits are employed with air, water or drilling mud to remove cuttings and cool the bit. Tri-cone bits are slightly smaller than the h les they drill (i.e., 5-7/8" or 7-7/8" bits will nominally drill 6" and 8" holes, respectively).

For obtaining split-barrel samples of a formation, samplers are manufactured in sizes ranging from 2-inches to 4-1/2 inches in outside diameter. However, the most commonly used size is the 2-inch O.D., 1-3/8-inch I.D. split-barrel sampler. When this sampler is used, and driven by a 140-pound (± 2 pound) hammer dropping 30-inches (± 1 inch), the procedure is called a Standard Penetration Test, and the blows per foot required to advance the sampler into the formation can be correlated to the formation's density or strength.

In planning the drilling of boreholes using hollow stem augers or casing, in which thin-wall tube samples or diamond core drilling will be performed, refer to the various sizes and clearances provided in Attachment A of this guideline. Sizes selected must be stated in the Work Plan.

5.2.12 Estimated Drilling Progress

To estimate the anticipated rates of drilling progress for a site the following must be considered:

- The speed of the drilling method employed.
- Applicable site conditions (e.g., terrain, mobility between borings, difficult drilling conditions in bouldery soils, rubble fill or broken rock, etc.).
- Project-imposed restrictions (e.g., drilling while wearing personal protective equipment, decontamination of drilling equipment, etc.).

Based on recent experience in drilling average soil conditions (no boulders) and taking samples at 5-foot intervals, for moderate depth (30' to 50') boreholes (not including installation or development of wells), the following daily rates of total drilling progress may be anticipated for the following drilling methods:

Drilling Method	Average Daily Progress (linear feet)
Hollow-stem augers	75'
Solid-stem augers	50'
Mud Rotary Drilling	100' (cuttings samples)
Reverse Circulation Rotary	100' (cuttings samples)
Skid Rig with driven casing	30'
Rotary with driven casing	50'
Cable Tool	30'
Hand Auger	Varies
Continuous Rock Coring	50'

5.3 PREVENTION OF CROSS-CONTAMINATION

A telescoping or multiple casing technique minimizes the potential for the migration of contaminated groundwater to lower strata below a confining layer. The telescoping technique consists of drilling to a confining layer utilizing a spun casing method with a diamond cutting or augering shoe, (a method similar to the rock coring method described in Section 5.2.9, except that larger casing is used) or a driven-casing method (see Section 5.2.5 of this guideline), and installing a specified diameter steel well casing. The operation consists of three separate steps. Initially, a drilling casing usually of 8-inch diameter is installed followed by installation of the well casing (6-inch diameter is common for 2-inch wells). This well casing is driven into the confining layer to insure a tight seal at the bottom of the hole. The well casing is sealed at the bottom with a bentonite-cement slurry. The remaining depth of the boring is drilled utilizing a narrower diameter spun or driven casing technique within the outer well casing. A smaller diameter well casing with an appropriate length of slotted screen on the lower end is installed to the surface.

Clean sand is placed in the annulus around and to a point about 2 feet above the screen prior t withdrawal of the drilling casing. The annular space above the screen and to a point 2 feet above the bottom of the outer well casing is sealed with a tremied cement-bentonite slurry which is pressur - grouted or displacement-grouted into the hole. The remaining casing annulus is backfilled with clean material and grouted at the surface, or it is grouted all the way to the surface.

5.4 CLEANOUT OF CASING PRIOR TO SAMPLING

The boring hole must be completely cleaned of disturbed soil, segregated coarse material and clay adhering to the inside walls of the casing. The cleaning must extend to the bottom edge of the casing and, if possible, a short distance further (1 or 2 inches) to bypass disturbed soil resulting from th advancement of the casing. Loss of wash water during cleaning should be recorded.

For disturbed samples both above and below the water table and where introduction of relatively large volumes of wash water is permissible, the cleaning operation is usually performed by washing the material out of the casing with water; however, tr cleaning should never be accomplished with a strong, downward directed jet which will disturb the underlying soil. When clean-out has reached the bottom of the casing or slightly below (as specified above), the string of tools should be lifted one foot off the bottom with the water still flowing, until the wash water coming out of the casing is clear of granular soil particles. In formations where the cuttings contain gravel and other larger particles, it is often useful to repeatedly raise and lower the drill rods and wash bit while washing out the h l , to surge these large particles upward out of the hole. As a time saver, the drilling contractor may b permitted to use a split barrel (split-spoon) sampler with the ball check valve removed as the clean out tool, provided the material below the spoon is not disturbed and the shoe of the spoon is not damaged. However, because the ball check valve has been removed, in some formations it may be necessary to install a flap valve or spring sample retainer in the split spoon bit, to prevent the sample from falling out as the sampler is withdrawn from the hole. The use of jet-type chopping bits is discouraged except where large boulders and cobbles or hard-cemented soils are encountered. If water markedly softens the soils above the water table, clean out should be performed dry with an auger.

For undisturbed samples below the water table, or where wash water must be minimized, clean out is usually accomplished with an appropriate diameter clean out auger. This auger has cutting blades at the bottom to carry loose material up into the auger, and up-turned water jets just above the cutting blades to carry the removed soil to the surface. In this manner there is a minimum of disturbance at the t p of the material to be sampled. If any gravel material washes down into the casing and cann t be removed by the cleanout auger, a split-barrel sample can be taken to remove it. Bailers and sandpumps should not be used. For undisturbed samples above the groundwater table, all operations must be performed in a dry manner.

If all of the cuttings created by drilling through the overlying formations are not cleaned from the borehole prior to sampling, some of the problems which may be encountered during sampling include:

- When sampling is attempted through the cuttings remaining in the borehole, all or part of the sampler may become filled with the cuttings. This limits the amount of sample from the underlying formation which can enter and be retained in the sampler, and also raises questions on the validity of the sample.

  If the cuttings remaining in the borehole contain coarse gravel and/or other large particles, these may block the bit of the sampler and prevent any materials from the underlying formation from entering the sampler when the sampler is advanced.

- In cased borings, should sampling be attempted through cuttings which remain in the lower portion of the casing, these cuttings could cause the sampler to become bound into the casing, such that it becomes very difficult to either advance or retract the sampler
- When sampler blow counts are used to estimate the density or strength of the formation being sampled, the presence of cuttings in the borehole will usually give erroneously high sample blow counts.

To confirm that all cuttings have been removed from the borehole prior to attempting sampling, it is important that the rig geologist measure the "stickup" of the drill string. This is accomplished by measuring the assembled length of all drill rods and bits or samplers (the drill string) as they are lowered to the bottom of the hole, below some convenient reference point of the drill string; then to measure the height of this reference point above the ground surface. The difference of these measurements is the depth of the drill string (lower end of the bit or sampler) below the ground surface, which must then be compared with the depth of sampling required (installed depth of casing or depth of borehole drilled). If the length of drill string below grade is more than the drilled or casing depth, the borehole has been cleaned too deeply, and this deeper depth of sampling must be recorded on the log. If the length of drill string below grade is less than the drilled or casing depth, the difference represents the thickness of cuttings which remain in the borehole. In most cases, an inch or two of cuttings may be left in the borehole with little or no problem. However, if more than a few inches for cuttings are encountered, the borehole must be recleaned prior to attempting sampling.

5.5 MATERIALS OF CONSTRUCTION

The effects of monitoring well construction materials on specific chemical analytical parameters are described and/or referenced in FT-7.01. However, there are several materials used during drilling, particularly drilling fluids and lubricants, which must be used with care to avoid compromising the representativeness of soil and ground water samples.

The use of synthetic or organic polymer slurries is not permitted at any location where soil samples f r chemical analysis are to be collected. These slurry materials could be used for installation of long term monitoring wells, but the early time data in time series collection of ground water data may then be suspect. If synthetic or organic polymer muds are proposed for use at a given site, a complete written justification including methods are procedures for their use must be provided by the site geologist and approved by the site manager. The specific slurry composition and the concentration f sel cted chemicals for each site must be known.

For many drilling operations, potable water is an adequate lubricant for drill stem and drilling tool connections. However, there are instances, such as drilling in tight clayey formations or in l ose gravels, when threaded couplings must be lubricated to avoid binding. In these instances, to be determined in the field at the judgment of the site geologist and noted in the Site Logbook, and only after approval by the site manager, a vegetable oil or silicone based lubricant should be used. Petroleum based greases, etc. will not be permitted. Samples of lubricants used must be provided and analyzed for chemical parameters appropriate to the given site.

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7.0 ATTACHMENTS

Attachment A - Drilling Equipment Sizes

ATTACHMENT A

DRILLING EQUIPMENT SIZES

Drilling Component	Designation or Hole Size (in)	O.D. (in)	I.D. (in)	Coupling I.D. (in)
Hollow-Stem	6 1/4	5	2 1/4	
Augers	6 3/4	5 3/4	2 3/4	-
•(Ref 7)	7 1/4	6 1/4	3 1/4	-
	13 1/4	12	6	-
Thin Wall	-	2	1 7/8	-
Tube Samplers	-	2 1/2	2 3/8	-
(Ref 7)	-	3	2 7/8	-
	-	3 1/2	3 3/8	-
	-	4 1/2	4 3/8	-
	-	5	4 3/4	-
Drill Rods	RW	1 3/32	23/32	13/32
(Ref 7)	EW	1 3/8	15/16	7/16
	AW	1 3/4	1 1/4	5/8
	BW	2 1/8	1 3/4	3/4
	NW	2 5/8	2 1/4	1 3/8
	HW	3 1/2	3 1/16	2 3/8
	E	1 5/16	7/8	7/16
	A	1 5/8	1 1/8	9/16
	B	1 7/8	1 1/4	5/8
	N	2 3/8	2	1
				Wall Thickness (in)
Driven External	2 1/2	2.875	2.323	0.276
C upled Extra	3	3.5	2.9	0.300
Str ng Steel*	3 1/2	4.0	3.364	0.318
Casing (Ref 8)	4	4.5	3.826	0.337
	5	5.63	4.813	0.375
	6	6.625	5.761	0.432
	8	8.625	7.625	0.500
	10	10.750	9.750	0.500
	12	12.750	11.750	0.500

Add twice the casing wall thickness to casing O.D. to obtain the approximate O.D. of the external pipe couplings.

ATTACHMENT A

DRILLING EQUIPMENT SIZES

Drilling Component	Designation or Hole Size (in)	O.D. (in)	I.D (in)	Coupling I.D. (in)
Flush Coupled Casing (Ref 7)	RX	1 7/16	1 3/16	1 3/16
	EX	1 13/16	1 5/8	1 1/2
	AX	2 1/4	2	1 29/32
	BX	2 7/8	2 9/16	2 3/8
	NX	3 1/2	3 3/16	3
	HX	4 1/2	4 1/8	3 15/16
Flush Joint Casing (Ref 7)	RW	1 7/16	1 3/16	
	EW	1 13/16	1 1/2	
	AW	2 1/4	1 29/32	
	BW	2 7/8	2 3/8	
	NW	3 1/2	3	
	HW	4 1/2	4	
	PW	5 1/2	5	
	SW	6 5/8	6	
	UW	7 5/8	7	
	ZW	8 5/8	8	
Diamond Core Barrels (Ref 7)	EWM	1 1/2	7/8 **	
	AWM	1 7/8	1 1/8 **	
	BWM	2 3/8	1 5/8 **	
	NWM	3	2 1/8	
	HWG	3 7/8	3	
	2 3/4 X 3 7/8	3 7/8	2 11/16	
	4 X 5 1/2	5 1/2	3 15/16	
	6 X 7 3/4	7 3/4	5 15/16	
	AQ (wireline)	1 57/64	1 1/16 **	
	BQ (wireline)	2 23/64	1 7/16 **	
	NQ (wireline)	2 63/64	1 7/8	
	HQ (wireline)	3 25/32	2 1/2	

** Because of the fragile nature of the core and the difficulty to identify rock details, use of small diameter cor (1 3/8") is not recommended.

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		Prepared Earth Sciences	
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1.0 PURPOSE

The purpose of this document is to establish standard procedures and technical guidance on borehole and sample logging.

2.0 SCOPE

These procedures provide descriptions of the standard techniques for borehole and sample logging. These techniques shall be used for each boring logged to provide consistent descriptions of subsurface lithology. While experience is the only method to develop confidence and accuracy in the description of soil and rock, the field geologist/engineer can do a good job of classification by careful, thoughtful observation and by being consistent throughout the classification procedure.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

Site Geologist - Responsible for supervising all boring activities and assuring that each borehole is completely logged. If more than one rig is being used onsite the Site Geologist must make sure that each field geologist is properly trained in logging procedures. A brief review or training session may be necessary prior to the start up of the field program and/or upon completion of the first boring.

5.0 PROCEDURES

The classification of soil and rocks is one of the most important jobs of the field geologist/engineer. To maintain a consistent flow of information, it is imperative that the field geologist/engineer understand and accurately use the field classification system described in this SOP. This identification is based on visual examination and manual tests.

5.1 MATERIALS NEEDED

Wh n logging soil and rock samples, the geologist or engineer may be equipped with the following:

- Rock hammer
- Knife
- Camera
- Dilute HCl
- Ruler (marked in tenths and hundreths of feet)
- Hand Lens

5.2 CLASSIFICATION OF SOILS

All data shall be written directly on the boring log (Exhibit 4-1) or in a field notebook if more space is needed. Details on filling out the boring log are discussed in Section 5.5.

5.2.1 USCS Classification

Soils are to be classified according to the Unified Soil Classification System (USCS). This method of classification is detailed in Exhibit 4-2. This method of classification identifies soil types on the basis of grain size and cohesiveness.

Fine-grained soils, or fines, are smaller than the No. 200 sieve and are of two types: silt (M) and clay (C). Some classification systems define size ranges for these soil particles, but for field classification purposes, they are identified by their respective behaviors. Organic material (O) is a common component of soil but has no size range; it is recognized by its composition. The careful study of the USCS will aid in developing the competence and consistency necessary for the classification of soils.

Coarse grained soils shall be divided into rock fragments, sand, or gravel. The terms and sand and gravel not only refer to the size of the soil particles but also to their depositional history. To insure accuracy in description, the term rock fragments shall be used to indicate angular granular materials resulting from the breakup of rock. The sharp edges typically observed indicate little or no transport from their source area, and therefore the term provides additional information in reconstructing the depositional environment of the soils encountered. When the term "rock fragments" is used it shall be followed by a size designation such as (1/4 inchΦ-1/2 inchΦ)" or "coarse-sand size" either immediately after the entry or in the remarks column. The USCS classification would not be affected by this variation in terms.

5.2.2 Color

Soil c lors shall be described utilizing a single color descriptor preceded, when necessary, by a modifier to denote variations in shade or color mixtures. A soil could therefore be referred to as "gray" or "light gray" or "blue-gray." Since color can be utilized in correlating units between sampling locations, it is important for color descriptions to be consistent from one boring to another.

Colors must be described while the sample is still moist. Soil samples shall be broken or split vertically to describe colors. Samplers tend to smear the sample surface creating color variations between the sampl interior and exterior.

The term "mottled" shall be used to indicate soils irregularly marked with spots of different colors. Mottling in soils usually indicates poor aeration and lack of good drainage.

Soil Color Charts shall not be used unless specified by the project manager.

5.2.3 Relative Density and Consistency

To classify the relative density and/or consistency of a soil, the geologist is to first identify the soil type. Granular soils contain predominantly sands and gravels. They are noncohesive (particles do not adher well when compressed). Finer grained soils (silts and clays) are cohesive (particles will adhere together when compressed).

The density of noncohesive, granular soils is classified according to standard penetration resistances obtained from split barrel sampling performed according to the methods detailed in Standard Operating Procedures GH-1.3 and SA-1.2. Those designations are:

Designation	Standard Penetration Resistance (Blows per Foot)
Very loose	0 to 4
Loose	5 to 10
Medium dense	11 to 30
Dense	31 to 50
Very dense	Over 50

Standard penetration resistance is the number of blows required to drive a split-barrel sampler with a 2-inch outside diameter 12 inches into the material using a 140 pound hammer falling freely through 30 inches. The sampler is driven through an 18-inch sample interval, and the number of blows is recorded for each 6-inch increment. The density designation of granular soils is obtained by adding the number of blows required to penetrate the last 12 inches of each sample interval. It is important to note that if gravel or rock fragments are broken by the sampler or if rock fragments are lodged in the tip, the resulting blow count will be erroneously high, reflecting a higher density than actually exists. This shall be noted on the log and referenced to the sample number. Granular soils are given the USCS classifications GW, GP, GM, SW, SP, SM, GC, and SC (see Exhibit 4-2).

The consistency of cohesive soils is determined by performing field tests and identifying th consistency as shown in Exhibit 4-3. Cohesive soils are given the USCS classifications ML, MH, CL, CH, OL, or OH (see Exhibit 4-2).

The consistency of cohesive soils is determined either by blow counts, a pocket penetrometer (values listed in the table as Unconfined Compressive Strength) or by hand by determining the resistance to pen tration by the thumb. The pocket penetrometer and thumb determination methods are conducted on a selected sample of the soil, preferably the lowest 0.5 foot of the sample in the split-barrel sampler. The sample shall be broken in half and the thumb or penetrometer pushed into the nd of the sample to determine the consistency. Do not determine consistency by attempting to penetrate a rock fragment. If the sample is decomposed rock, it is classified as a soft decomposed rock rather than a hard soil. Consistency shall not be determined solely by blow counts. One of th other methods shall be used in conjunction with it. The designations used to describe the consistency of cohesive soils are as follows:

Consistency	Unc. Compressive Str. Tons/Square Foot	Standard Penetration Resistance (Blows per Foot)	Field Identification Methods
Very soft	Less than 0.25	0 to 2	Easily penetrated several inches by fist
Soft	0.25 to 0.50	2 to 4	Easily penetrated several inches by thumb
Medium stiff	0.50 to 1.0	4 to 8	Can be penetrated several inches by thumb
Very stiff	1.0 to 2.0	8 to 15	Readily indented by thumb
Hard	2.0 to 4.0	15 to 30	Readily indented by thumbnail
Hard	M re than 4.0	Over 30	Indented with difficulty by thumbnail

5.2.4 Weight Percentages

In nature, soils are comprised of particles of varying size and shape, and are combinations of the various grain types The following terms are useful in the description of soil:

Terms of Identifying Proportion of the Component	Defining Range of Percentages by Weight
trace	0 - 10 percent
some	11 - 30 percent
and or adjective form of the soil type (e.g., "sandy")	31 - 50 percent

Exampl s:

- Silty fine sand: 50 to 69 percent fine sand, 31 to 50 percent silt.

  Medium to coarse sand, some silt: 70 to 80 percent medium to coarse sand, 11 to 30 percent silt.

  Fine sandy silt, trace clay: 50 to 68 percent silt, 31 to 49 percent fine sand, 1 to 10 percent clay.

- Clayey silt, some coarse sand: 70 to 89 percent clayey silt, 11 to 30 percent coarse sand.

5.2.5 Moisture

Moisture content is estimated in the field according to four categories: dry, moist, wet, and saturated. In dry soil, there appears to be little or no water. Saturated samples obviously have all the water they can hold. Moist and wet classifications are somewhat subjective and often are determined by the individual's judgment. A suggested parameter for this would be calling a soil wet if rolling it in the hand or on a porous surface liberates water, i.e., dirties or muddies the surface. Whatever m thod is adopted for describing moisture, it is important that the method used by an individual remains consistent throughout an entire drilling job.

Laboratory tests for water content shall be performed if the natural water content is important.

5.2.6 Stratification

Stratification can only be determined after the sample barrel is opened. The stratification or bedding thickness for soil and rock is depending on grain size and composition. The classification to be used for stratification description is shown in Exhibit 4-4.

5.2.7 Texture/Fabric/Bedding

The texture/fabric/bedding of the soil shall be described. Texture is described as the relative angularity of the particles: rounded, subrounded, subangular, and angular. Fabric shall be noted as to whether the particles are flat r bulky and whether there is a particular relation between particles (i.e., all the flat particles are parallel or there is some cementati n). The b dding r structure shall also be n ted (e.g., stratified, lensed, n nstratified, heterogeneous varved).

5.2.8 Summary of Soil Classification

In summary, soils shall be classified in a similar manner by each geologist/engineer at a project site The hierarchy of classification is as follows:

- Density and/or consistency
- Color
- Plasticity (Optional)
- Soil types
  Moisture content
- Stratification
- Texture, fabric, bedding
  Other distinguishing features

5.3 CLASSIFICATION OF ROCKS

Rocks are grouped into three main divisions, including sedimentary, igneous and metamorphic rocks. Sedimentary rocks are by far the predominant type exposed at the earth's surface. The following basic names are applied to the types of rocks found in sedimentary sequences:

- Sandstone - Made up predominantly of granular materials ranging between 1/16 to 2 mm in diameter.
- Siltstone - Made up of granular materials less than 1/16 to 1/256 mm in diameter. ractures irregularly. Medium thick to thick bedded.
- Claystone - Vary fine grained rock made up of clay and silt-size materials. Fractures irregularly. Very smooth to touch. Generally has irregularly spaced pitting on surface of drilled cores.
- Shale - A fissile very fine grained rock. Fractures along bedding planes.
- Limestone - Rock made up predominantly of calcite ($CaCO_3$). Effervesces strongly upon the application of dilute hydrochloric acid.
- Coal - Rock consisting mainly of organic remains.
- Others - Numerous other sedimentary rock types are present in lesser amounts in the stratigraphic record. The local abundance of any of these rock types is dependent upon the depositional history of the area. These include conglomerate, halite, gypsum, dolomite, anhydrite, lignite, etc. are some of the rock types found in lesser amounts.

In classifying a sedimentary rock the following hierarchy shall be noted:

- Rock type
- Color
- Bedding thickness
- Hardness
- Fracturing
- Weathering
  Other characteristics

5.3.1 Rock Type

As described above, there are numerous names of sedimentary rocks. In most cases a rock will be a combination of several grain types, therefore, a modifier such as a sandy siltstone, or a silty sandstone can be used. The modifier indicates that a significant portion of the rock type is composed of the modifier. Other modifiers can include carbonaceous, calcareous, siliceous, etc.

Grain size is the basis for the classification of clastic sedimentary rocks. Exhibit 4-5 is the Udden-Wentworth classification that will be assigned to sedimentary rocks. The individual boundaries are slightly different than the USCS subdivision for soil classification. For field determination of grain sizes, a scale can be used for the coarse grained rocks. For example, the division between siltstone and claystone may not be measurable in the field. The boundary shall be determined by use of a hand lens. If the grains cannot be seen with the naked eye but are distinguishable with a handlens, the rock is a siltstone. If the grains are not distinguishable with a handlens, the rock is a claystone.

5.3.2 Color

The color of a rock can be determined in a similar manner as for soil samples. Rock core samples shall be classified while wet, when possible, and air cored samples shall be scraped clean of cuttings prior t c lor classifications.

Rock Color Charts shall not be used unless specified by the project manager.

5.3.3 Bedding Thickness

The bedding thickness designations applied to soil classification will also be used for rock classification.

5.3.4 Hardness

The hardness of a rock is a function of the compaction, cementation, and mineralogical composition of the rock. A relative scale for sedimentary rock hardness is as follows:

> Soft - Weathered, considerable erosion of core, easily gouged by screwdriver, scratched by fingernail. Soft rock crushes or deforms under pressure of a pressed hammer. This t rm is always used for the hardness of the saprolite (decomposed rock which occupies the zone between the lowest soil horizon and firm bedrock).
>
> Medium soft - Slight erosion of core, slightly gouged by screwdriver, or breaks with crumbly edges from single hammer blow.
>
> Medium hard - No core erosion, easily scratched by screwdriver, or breaks with sharp edges from single hammer blow.
>
> Hard - Requires several hammer blows to break and has sharp conchoidal breaks. Cannot be scratched with screwdriver.

Note the difference in usage here of the works "scratch" and "gouge." A scratch shall be considered a slight depression in the rock (do not mistake the scraping off of rock flour from drilling with a scratch in the rock itself), while a gouge is much deeper.

5.3.5 Fracturing

The degree of fracturing or brokeness of a rock is described by measuring the fractures or joint spacing. After eliminating drilling breaks, the average spacing is calculated and the fracturing is described by the following terms:

Very broken (V. BR.) - Less than 2 in. spacing between fractures
Broken (BR) - 2 in. to 1 ft. spacing between fractures
Blocky (BL.) - 1 to 3 ft. spacing between fractures
Massive (M.) - 3 to 10 ft. spacing between fractures

The structural integrity of the rock can be approximated by calculating the Rock Quality Designation (RQD) of cores recovered. The RQD is determined by adding the total lengths of all pieces exceeding 4 inches and dividing by the total length of the coring run, to obtain a percentage.

Method of Calculating RQD
(After Deere, 1964)

RQD % = r/l x 100

r = Total length of all pieces of the lithologic unit being measured, which are greater than 4 inches length, and have resulted from natural breaks. Natural breaks include slickensides, joints, compaction slicks, bedding plane partings (not caused by drilling), friable zones, etc.

l = Total length of the coring run.

5.3.6 Weathering

The degree of weathering is a significant parameter that is important in determining weathering profiles and is also useful in engineering designs. The following terms can be applied to distinguish the degree of weathering:

Fresh - Rock shows little or no weathering effect. Fractures or joints have little or no staining and rock has a bright appearance.

- Slight - Rock has some staining which may penetrate several centimeters into the rock. Clay filling of joints may occur. Feldspar grains may show some alteration.
- Moderate - Most of the rock, with exception of quartz grains, is stained. Rock is weakened due to weathering and can be easily broken with hammer.
- Severe - All rock including quartz grains is stained. Some of the rock is weathered to the extent of becoming a soil. Rock is very weak.

5.3.7 Other Characteristics

The following items shall be included in the rock description:

- Description of contact between two r ck units. These can be sharp or gradational.
- Stratificati n (parallel, cross stratified)
- Descripti n of any filled cavities or vugs
  Cementation (calcore us, siliceous, hematitic)

Description of any joints or open fractures.
Observation of the presence of fossils.
Notation of joints with depth, approximate angle to horizontal, any mineral filling or coating, and degree of weathering.

All information shown on the boring logs shall be neat to the point where it can be reproduced on a copy machine for report presentation. The data shall be kept current to provide control of the drilling program and to indicate various areas requiring special consideration and sampling.

5.3.8 Additional Terms Used in the Description of Rock

The following terms are used to further identify rocks:

Seam - Thin (12 inch or less), probably continuous layer.

Some - Indicates significant (15 to 40 percent) amounts of the accessory material. For example, rock composed of seams of sandstone (70 percent) and shale (30 percent) would be "sandstone -- some shale seams."

Few - Indicates insignificant (0 to 15 percent) amounts of the accessory material. For example, rock composed of seam of sandstone (90 percent) and shale (10 percent) would be "sandstone -- few shale seams."

- Interbedded - Used to indicate thin or very thin alternating seams of material occurring in approximately equal amounts. For example, rock composed of thin alternating seams of sandstone (50 percent) and shale (50 percent) would be "interbedded sandstone and shale."

Interlayered - Used to indicate thick alternating seams of material occurring in approximately equal amounts.

The preceding sections describe the classification of sedimentary rocks. The following are some basic names that are applied to igneous rocks:

- Basalt - A fine-grained extrusive rock composed primarily of calcic plagioclase and pyroxene.

Rhyolite - A fine-grained volcanic rock containing abundant quartz and orthoclase. The fine-grained equivalent of a granite.

- Granite - A coarse-grained plutonic rock consisting essentially of alkali feldspar and quartz.

Diorite - A coarse-grained plutonic rock consisting essentially of sodic plagioclase and hornblende.

- Gabbro - A coarse-grained plutonic rock consisting of calcic plagioclase and clinopyroxene. Loosely used for any coarse grained dark igneous rock.

The f llowing are some basic names that are applied to metamorphic rocks:

Slate - A very fine-grained foliated rock possessing a well developed slaty cleavage. Contains predominantly chlorite, mica, quartz, and sericite.

Phyllite - A fine-grained foliated rock that splits into thin flaky sheets with a silky sheen on cleavage surface.

Schist - A medium to coarse-grained foliated rock with subparallel arrangement of the micaceous minerals which dominate its composition.

Gneiss - A coarse-grained foliated rock with bands rich in granular and platy minerals.

- Quartzite - A fine to coarse-grained nonfoliated rock breaking across grains, consisting essentially of quartz sand with silica cement.

5.4 ABBREVIATIONS

Abbreviations may be used in the description of a rock or soil. However, they shall be kept at a minimum. Following are some of the abbreviations that may be used:

C - Coarse	Lt - Light	Yl - Yellow
Med - Medium	BR - Broken	Or - Orange
F - Fine	BL - Blocky	SS - Sandstone
V - Very	M - Massive	Sh - Shale
Sl - Slight	Br - Brown	LS - Limestone
Occ - Occasional	Bl - Black	Fgr - Fine grained
Tr - Trace		

5.5 BORING LOGS AND DOCUMENTATION

This section describes in more detail the procedures to be used in completing boring logs in the field. Information obtained from the preceeding sections shall be used to complete the logs. A sample b ring log has been provided as Exhibit 4-6. The field geologist/engineer shall use this example as a guide in completing each borings log. Each boring log shall be fully described by the geologist/engineer <u>as the boring is being drilled</u>. Every sheet contains space for 25 feet of log. Information regarding classification details is provided on the back of the boring log, for field use.

5.5.1 Soil Classification

Identify site name, boring number, job number, etc. Elevations and water level data to b entered when surveyed data is available.

- Enter sample number (from SPT) under appropriate column. Enter depth sample was taken from (1 block = 1 foot). Fractional fo tages, i.e., change of lith logy a 13.7 feet, shall be lined off at the prop rtional locati n between the 13 and 14 foot marks. Enter blow counts (Standard Penetration Resistance) diagonally (as shown). Standard penetration resistance is covered in Section 5.2.3.

- Determine sample recovery/sample length as shown. Measure the total length of sample recovered from the split spoon sampler, including material in the drive shoe. Do not include cuttings or wash material that may be in the upper portion of the sample tube.

- Indicate any change in lithology by drawing a line at the appropriate depth. For example, if clayey silt was encountered from 0 to 5.5 feet and shale from 5.5 to 6.0 feet, a line shall be drawn at this increment. This information is helpful in the construction of cross-sections. As an alternative, symbols may be used to identify each change in lithology.

  The density of granular soils is obtained by adding the number of blows for the last two increments. Refer to Density of Granular Soils Chart of back of log sheet. For consistency of cohesive soils refer also to the back of log sheet - Consistency of Cohesive Soils. Enter this information under the appropriate column. Refer to Section 5.2.3.

  Enter color of the material in the appropriate column.

  Describe material using the USCS. Limit this column for sample description only. The predominate material is described last. If the primary soil is silt but has fines (clay) - use clayey silt. Limit soil descriptors to the following:

  - Trace 0 - 10 percent
  - Some 11 - 30 percent
  - And 31 - 50 percent

- Also indicate under Material Classification if the material is fill or natural soils. Indicate roots, organic material, etc.

  Enter USCS symbol - use chart on back of boring log as a guide. If the soils fall into one of two basic groups, a borderline symbol may be used with the two symbols separated by a slash. For example ML/CL or SM/SP.

- The following information shall be entered under the Remarks Column and shall include, but is not limited by the following:

  - Moisture - estimate moisture content using the following terms - dry, moist, wet and saturated. These terms are determined by the individual. Whatever method is used to determine moisture, be consistent throughout the log.

  - Angularity - describe angularity of coarse grained particles using Angular, Subangular, Subrounded, Rounded. Refer to ASTM D 2488 or Earth Manual for criteria for these terms.

  - Particle shape - flat, elongated, or flat and elongated.

  - Maximum particle size or dimension.

  - Water level observations.

  - Reaction with HCl - none, weak or strong.

Additional comments:

- Indicate presence of mica, caving of hole, when water was encountered, difficulty in drilling, loss or gain of water.

- Indicate odor and HNu or OVA reading if applicable.

- Indicate any change in lithology by drawing in line through the lithology change column and indicate the depth. This will help later on when cross-sections are constructed.

- At the bottom of the page indicate type of rig, drilling method, hammer size and drop and any other useful information (i.e., borehole size, casing set, changes in drilling method).

- Vertical lines shall be drawn (as shown in Exhibit 4.6) in columns 5 to 8 from the bottom of each sample to the top of the next sample to indicate consistency of material from sample to sample, if the material is consistent. Horizontal lines shall be drawn if there is a change in lithology, then vertical lines drawn to that point.

- Indicate screened interval of well, as needed, in the lithology column. Show top and bottom of screen. Other details of well construction are provided on the w ll construction forms.

5.5.2 Rock Classification

Indicate depth at which coring began by drawing a line at the appropriate depth. Indicate core run depths by drawing coring run lines (as shown) under the first and fourth columns on the log sheet. Indicate RQD, core run number, RQD percent and core recovery und r the appropriate columns.

- Indicate lithology change by drawing a line at the appropriate depth as explained in Section 5.5.1.

- Rock hardness is entered under designated column using terms as described on the back of the log or as explained earlier in this section.

  Enter color as determined while the core sample is wet; if the sample is cored by air, the core shall be scraped clean prior to describing color.

  Enter rock type based on sedimentary, igneous or metamorphic. For sedimentary rocks use terms as described in Section 5.3. Again, be consistent in classification. Use modifiers and additional terms as needed. For igneous and metamorphic rock types use terms as described in Sections 5.3.8.

- Enter brokeness of rock or degree of fracturing under the appropriate column using symbols VBR, BR, BL, or M as explained in Section 5.3.5 and as noted on the back of the Boring Log.

- The following information shall be entered under the remarks column Items shall include but are not limited to the following:

  - Indicate depths of joints, fractures and breaks and also approximate to horizontal angle (such as high, low), i.e., 70° angle from horizontal, high angle.
  - Indicate calcareous zones, description of any cavities or vugs.
  - Indicate any loss or gain of drill water.
  - Indicate drop of drill tools or change in color of drill water

  Remarks at the bottom of Boring Log shall include:

  - Type and size of core obtained.
  - Depth casing was set.
  - Type of Rig used.

  As a final check the boring log shall include the following:

  - Vertical lines shall be drawn as explained for soil classification to indicate consistency of bedrock material.

  - If applicable, indicate screened interval in the lithology column. Show top and bottom of screen. Other details of well construction are provided on the well construction forms.

5.5.3 Classification of Soil and Rock from Drill Cuttings

The previous sections describe procedures for classifying soil and rock samples when cores are obtained. However, some drilling methods (air/mud rotary) may require classification and borehole logging based on identifying drill cuttings removed from the borehole. Such cuttings provide only general information on subsurface lithology. Some procedures that shall be followed when logging cuttings are:

Obtain cutting samples at approximately 5 foot intervals, sieve the cuttings (if mud rotary drilling) to obtain a cleaner sample, place the sample into a small sample bottle or "zip lock" bag for future reference, and label the jar or bag (i.e. hole number, depth, date etc.). Cuttings shall be closely examined to determine general lithology.

Note any change in color of drilling fluid or cuttings, to estimate changes in lithology

Note drop or chattering of drilling tools or a change in the rate of drilling, to determine fracture locations or lithologic changes.

Observe loss or gain of drilling fluids or air (if air rotary methods are used), to identify potential fracture zones.

Record this and any other useful information onto the boring log as provided in Exhibit 4-1.

This logging provides a general descripti n of subsurface lithology and adequate information can be obtained through careful observation of the drilling process. It is recommended that split barrel and r ck c re sampling methods be used at selected boring locations during the field investigation to provide detailed information to supplement the less detailed data generated through borings drilled using air/mud rotary methods.

5.6 REVIEW

Upon completion of the borings logs, copies shall be made and reviewed. Items to be reviewed include:

- Checking for consistency of all logs
  Checking for conformance to the guideline
  Checking to see that all information is entered in their respective columns and spaces

6.0 REFERENCES

Unified Soil Classification System (USCS)

ASTM D2488, 1985

Earth Manual, U.S. Department of the Interior, 1974

7.0 RECORDS

Originals of the boring logs shall be retained in the project files.

EXHIBIT 4-1

BORING LOG — **NUS CORPORATION**

PROJECT BORING NO

PROJECT NO DATE DRILLER

ELEVATION FIELD GEOLOGIST

WATER LEVEL DATA

(Date, Time & Conditions)

SAMPLE NO. & TYPE OR RQD	DEPTH (ft) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY /SAMPLE LENGTH	LITHOLOGY CHANGE (Depth,ft.) OR SCREENED INTERVAL	MATERIAL DESCRIPTION: SOIL DENSITY/ CONSISTENCY OR ROCK HARDNESS	MATERIAL DESCRIPTION: COLOR	MATERIAL DESCRIPTION: MATERIAL CLASSIFICATION	USCS OR ROCK BROKENESS	REMARKS

REMARKS ______________________________

BORING ________

PAGE ____ OF ____

EXHIBIT 4-2

SOIL TERMS

UNIFIED SOIL CLASSIFICATION (USCS)

COARSE GRAINED SOILS

More than half of material is LARGER than No. 200 sieve size

		FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 3" & basing fractions on estimated weights)	GROUP SYMBOL	TYPICAL NAMES
GRAVELS 50%(+)> 1/4"Ø	CLEAN GRAVELS (Low % fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes.	GW	Well graded gravels, gravel sand mixtures, little or no fines.
		Predominantly one size or a range of sizes with some intermediate sizes missing.	GP	Poorly graded gravels, gravel sand mixtures, little or no fines.
	GRAVELS W/FINES (High % fines)	Non plastic fines (for identification procedures see ML)	GM	Silty gravels, poorly graded gravel sand silt mixtures.
		Plastic fines (for identification procedures see CL)	GC	Clayey gravels, poorly graded gravel sand-clay mixtures.
SANDS 50%(+)< 1/4"Ø	CLEAN SANDS (Low % fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes.	SW	Well graded sand, gravelly sands, little or no fines.
		Predominantly one size or a range of sizes with some intermediate sizes missing.	SP	Poorly graded sands, gravelly sands, little or no fines.
	SANDS W/FINES (High % fines)	Non plastic fines (for identification procedures see ML)	SM	Silty sands, poorly graded sand silt mixtures.
		Plastic fines (for identification procedures see CL)	SC	Clayey sands, poorly graded sand clay mixtures.

FINE GRAINED SOILS

More than half of material is SMALLER than No. 200 sieve size

	FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 3" & basing fractions on estimated weights)			GROUP SYMBOL	TYPICAL NAMES
	Identification procedures on fraction smaller than No. 40 sieve size				
	DRY STRENGTH (Crushing Characteristics)	DILATANCY (Reaction to Shaking)	TOUGHNESS (Consistency Near Plastic Limit)		
SILTS & CLAYS Liquid limit < 50	None to slight	Quick to slow	None	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity
	Medium to high	None to very slow	Medium	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
	Slight to medium	Slow	Slight	OL	Organic silts and organic silt-clays of low plasticity
SILTS & CLAYS Liquid limit > 50	Slight to medium	Slow to none	Slight to medium	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
	High to very high	None	High	CH	Inorganic clays of high plasticity, fat clays
	Medium to high	None to very slow	Slight to medium	OH	Organic clays of medium to high plasticity
HIGHLY ORGANIC SOILS	Readily identified by color, odor, spongy feel and frequently by fibrous texture			Pt	Peat and other organic soils

Boundary classifications: Soils possessing characteristics of two groups are designated by combining group symbols. For example GW-GC, well graded gravel-sand mixture with clay binder.
All sieve sizes on this chart are U.S. standard.

DENSITY OF GRANULAR SOILS

DESIGNATION	STANDARD PENETRATION RESISTANCE - BLOWS/FOOT
Very loose	0-4
Loose	5-10
Medium dense	11-30
Dense	31-50
Very dense	Over 50

CONSISTENCY OF COHESIVE SOILS

CONSISTENCY	UNC. COMPRESSIVE STR. TONS/SQ. FT.	STANDARD PENETRATION RESISTANCE - BLOWS/FOOT	FIELD IDENTIFICATION METHODS
Very soft	Less than 0.25	0 to 2	Easily penetrated several inches by fist
Soft	0.25 to 0.50	2 to 4	Easily penetrated several inches by thumb
Medium stiff	0.50 to 1.0	4 to 8	Can be penetrated several inches by thumb
Stiff	1.0 to 2.0	8 to 15	Readily indented by thumb
Very stiff	2.0 to 4.0	15 to 30	Readily indented by thumbnail
Hard	More than 4.0	Over 30	Indented with difficulty by thumbnail

ROCK TERMS

ROCK HARDNESS (FROM CORE SAMPLES)

DESCRIPTIVE TERMS	SCREWDRIVER OR KNIFE EFFECTS	HAMMER EFFECTS
Soft	Easily gouged	Crushes when pressed with hammer
Medium soft	Can be gouged	Breaks (one blow) Crumbly edges
Medium hard	Can be scratched	Breaks (one blow) Sharp edges
Hard	Cannot be scratched	Breaks conchoidally (several blows) Sharp edges

ROCK BROKENNESS

DESCRIPTIVE TERMS	ABBREVIATION	SPACING
Very broken	(V. Br.)	0-2"
Broken	(Br.)	2"-1'
Blocky	(Bl.)	1'-3'
Massive	(M.)	3'-10'

LEGEND

SOIL SAMPLES - TYPES

S 2" O.D. Split Barrel Sample
ST 3" O.D. Undisturbed Sample
O Other Samples, Specify in Remarks

ROCK SAMPLES - TYPES

X NX (Conventional) Core (~2 1/8" O.D.
Q NQ (Wireline) Core (~1 7/8" O.D.)
Z Other Core Sizes, Specify in Remarks

WATER LEVELS

12/18
▽ 12.6 Initial Level w/Date & Depth

12/18
▼ 12.6' Stabilized Level w/Date & Depth

EXHIBIT 4-3

CONSISTENCY FOR COHESIVE SOILS

Consistency	(Blows per Foot)	Unconfined Compressive Strength (tons/square foot by pocket penetration	Field Identification
Very soft	0 to 2	Less than 0.25	Easily penetrated several inches by fist
Soft	2 to 4	0.25 to 0.50	Easily penetrated several inches by thumb
Medium stiff	4 to 8	0.50 to 1.0	Can be penetrated several inches by thumb with moderate effort
Stiff	8 to 15	1.0 to 2.0	Readily indented by thumb but penetrated only with great effort
Very stiff	15 to 30	2.0 to 4.0	Readily indented by thumbnail
Hard	Over 30	More than 4.0	Indented by thumbnail

EXHIBIT 4-4

BEDDING THICKNESS CLASSIFICATION

Thickness (Metric)	Thickness (Approximate English Equivalent)	Classification
> 1 0 meter	> 3.3′	Massive
30 cm - 1 meter	1.0′ - 3.3′	Thick Bedded
10 cm - 30 cm	4″ - 1.0′	Medium Bedded
3 cm - 10 cm	1″ - 4″	Thin Bedded
1 cm - 3 cm	2/5″ - 1″	Very Thin Bedded
3 mm - 1 cm	1/8″ - 2/5″	Laminated
1 mm - 3 mm	1/32″ - 1/8″	Thinly Laminated
< 1 mm	< 1/32″	Micro Laminated

(Weir, 1973 and Ingram, 1954)

EXHIBIT 4-5

GRAIN SIZE CLASSIFICATION FOR ROCKS

Particle Name	Grain Size Diameter
Cobbles	> 64 mm
Pebbles	4-64 mm
Granules	2-4 mm
Very Coarse Sand	1-2 mm
Coarse Sand	0.5-1 mm
Medium Sand	0.25-0.5 mm
Fine Sand	0.125-0.25 mm
Very Fine Sand	0.0625-0.125 mm
Silt	0.0039-0.0625 mm

After Wentworth, 1922

BORING LOG — **NUS CORPORATION**

PROJECT HEBELKA SITE — BORING NO MW 3A
PROJECT NO 619Y — DATE 9-21-87 — DRILLER B. GOLLIHUE
ELEVATION 510.07 — FIELD GEOLOGIST SJ CONTI
WATER LEVEL DATA (Date, Time & Conditions) WL 26.35 - TPVC 10-16-87

SAMPLE NO & TYPE/ RQD	DEPTH (FT) / RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY/ SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft) OR SCREEN INT	MATERIAL DESCRIPTION*: SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK OR BRKNESS / USCS	REMARKS
S-1	0.0	3 / 6	1.5/1.5		STIFF	BRN	CLAYEY SILT – TR SHALE	ML	0-6" TOPSOIL MOIST 0PPM
	1.5	6					FRAG – TR ORG.		RESIDUAL SOIL.
	5.0								
S-2	6.0	11 / 100/.5	0.8/1.0	5.5 / 6.0	M.SOFT	GRAY BRN	DEC SHALE AND SILT	VBR	DAMP 0PPM
					TO				REFUSAL @ 6' 5.5 TOP OF DEC
					M.HARD				ROCK
									AUGERED TO 15' W/SOLID STEM AUG
									CUTTING MOIST @ ≈8' WATER @ 11'±
									WL @ 12.10 PM WAS
									≈ 9' FROM GS.
									SET 4" PVC CAS. @ 15.0'
9-21	15.0								
9-22					M.HARD	BRN GRAY	SILTY SHALE – FEW	VBR	SEVERAL 0 PPM
							QUARTZ PCS		Fe STAINED JOINTS \ ON CORE
									THRUOUT RUN JOINTS AND BREAKS
									ARE HORIZ TO LO ∠. W/VUGS ON LOWER
0.7/10.0	①	0%/%	7.9/10.0						PORTION 23 TO 25 OF CORE
	25.0								

REMARKS ACKER AD II RIG - SOLID STEM AUGERS USED TO ADVANCE BORING - 140 LB WT & 30" DROP - TO TAKE 2"Φ SP SPOON SAMPLES - SET UP OVER HOLE @ 11:10 AM. WILL SAMPLE THIS HOLE - SET 4" CASING THEN DO SHALLOW WELL. STARTED TO CORE 9-22-87 USING THE WIRE-LINE CORING METHOD.

BORING MW 3A

PAGE 1 OF 3

* See Legend on Back

D334901

BORING LOG — NUS CORPORATION

PROJECT HEBELKA SITE — BORING NO MW 3A
PROJECT NO 619Y — DATE 9-22-87 — DRILLER B. GOLLIHUE
ELEVATION — FIELD GEOLOGIST SJ CONTI
WATER LEVEL DATA
(Date, Time & Conditions)

	SAMPLE NO & TYPE / RQD	DEPTH (ft) / RUN	BLOWS / 6" OR RQD (%)	SAMPLE RECOVERY / SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft)	MATERIAL DESCRIPTION*: SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
9-22		25.0				M.HARD	GRAY	SILTY SHALE	VBR	SHALE IS VBR W/ HORIZ TO LO ∠ JNTS
								(SILTSTONE)		≈26 TO 27 2- VERT
								-FEW QUARTZ		JOINTS. IRON STAINS ON JNTS
								SEAMS		ROCK BECOMES AND BREAKS MORE LIKE
										A SILTSTONE WITH DEPTH.
	0/10.0	②	0%	8.7/10.0						
									BR	≈32 TO 33 FEW QUARTZ PIECES W/
									VBR	VUGS. SL. MICACEOUS
										VF QUARTZ GRAINS IN MATRIX- 30X MAG.
		35.0								≈34 TO 35 · 2 VERT JOINTS
						M.HARD	GRAY	SILTY SHALE (SILTSTONE)	VBR	35.0-35.5 QUARTZ PIECES
								-FEW QUARTZ	BR	
								SEAMS	VBR	BECOMES SL. CALCAR. @ 37± THIN CALCITE
										LAMINATIONS WATER STAINED JNTS
									BR	THRUOUT RUN MORE SO 35-37±
	1.0/10.0	③	10%	9.3/10.0					VBR	39.5 → 42.0
										42.7→43.0 HI ∠ JNT
									BR	42.4→42.7 VERT JNT
		45.0							VBR	
										45.3→45.5 VERT JNT. & VBR
										47.5 VERT JOINT
									BR	48. HI ∠ JOINT
										SLIGHTLY CALCAREOUS MORE CALCITE
										PRESENT

REMARKS ____________________

BORING MW 3A

PAGE 2 OF 3

* See Legend on Back

BORING LOG — **NUS CORPORATION**

PROJECT HEBELKA SITE — BORING NO MW 3A
PROJECT NO 619Y — DATE 9-22-87 — DRILLER B. GOLLIHUE
ELEVATION — FIELD GEOLOGIST SJ CONTI
WATER LEVEL DATA
(Date, Time & Conditions)

SAMPLE NO & TYPE	DEPTH (FT)	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft)	SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
1.9/10.0	④	19%/0	10.0/10.0		M.HARD	GRAY	SILTY SHALE (SILTSTONE)	VBR	50.5 → 51.0 VBR
							SL. CALCAREOUS	BR	51.5 → 54.0 BR w/ SEV LO & JOINTS
	55.0								
								VBR	POOR RECOVERY W/ SOFT ZONES.
0/1	⑤	0%/0	1.8/10.0						
	65.0								
				66					
									63.5- DRILLER NOTED SOFT AREA - LOSS OF 1/3 OF WATER - CHANGE IN COLOR OF DRILL WATER TO YELLOW BROWN
0/0	⑥	0%/0	1.3/10.0						
									POOR RECOVERY
									FEW CALCAREOUS ZONES.
	75.0			76					

REMARKS AT 75' @ 1:45 PM - PULLING TOOLS - TO REAM HOLE.
AT 1:50 PM CORED HOLE TO 75' REAMED TWICE
DUE TO RUNNING SAND (FRACTURE) AT ≈ 68. REAMED
2ND TIME TO 81'. SET WELL 66'-76'.

BORING MW 3A
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* See Legend on Back

EXHIBIT 4-6

BORING LOG — **NUS CORPORATION**

PROJECT: WESTLINE SITE — BORING NO: MW 013
PROJECT NO: 473 Y — DATE: 7-7-87 — DRILLER: B ERICSON
ELEVATION: 1462.37 — FIELD GEOLOGIST: SJ CONTI — PENN - DRILL
WATER LEVEL DATA: 5.54' @ 8 50 AM 7-23-87 T-PVC — ACKER AD-II
(Date, Time & Conditions)

SAMPLE NO & TYPE OR RQD	DEPTH (FT) OR RUN NO	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft) OR SCREEN INT	MATERIAL DESCRIPTION: SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS OR ROCK BRKNESS	REMARKS (HNU) HEAD SP
	0.0	5 / 3	1.4/1.5		LOOSE	BLK BRN	CLAYEY SILT AND CINDER	ML	MOIST (0PPM)
S-1		2					TR COAL FRGS		3/4 Φ FRAGS - NEAR OLD RR. LINE.
							TR-CC FRAG		
							(FILL)		
	5.0					RED			
S-2		1 / 1	1.3/1.5	6.0	V. LOOSE	BRN TO	SANDY SILT-TR FRGS TO	SM	MOIST TO WET (0PPM)
	6.5	3				GRAY	SILTY SAND-TR GRAVEL		GRAY SAND @ 6' ± MICACEOUS 1.22 ± NATURAL
									DRILLER NOTE H2O 8-10'
	10.0								
S-3		11 / 23	1.2/1.5		DENSE	BRN	SILTY SAND AND S.S	GM	WET (0PPM)
	11.5	27					FRAGS (GRAV)		1" Φ SIZE MAX SIZE SUBANGULAR TO SUBROUNDED GRAVEL
	15.0								
S-4		7 / 47	1.0/1.5		V. DENSE	BRN	SILTY FINE TO C. SAND	SM	WET (0PPM)
	16.5	43					AND GRAVEL		1' Φ SIZE MAX SIZE SUBANGULAR TO SUBROUNDED GRAVEL
	20.0								
S-5	20.9	17 / 50/.4	.4/.9		V DENSE	ORANG BRN	SILTY SAND - SOME	GM	WET (0PPM)
							GRAVEL AND		MOIST
							S.S FRAGS		BECOMES MORE LIKE SANDY SILT AT BOTM. OF SAMPLE

REMARKS: START @ 1:15 PM - 7-7-87 USING 4¼" ID HOLLOW STEMS
S-4 @ 3:30 PM TO ADVANCE THE BORING USING
S-5 @ 4:30 PM ACKER DRILL - MOUNTED ON
FORD 8000 TRUCK
SAMPLES TAKEN USING 140 lb WT AND 30 INCH DROP.

BORING MW 013
PAGE 1 OF 4

BORING LOG — **NUS CORPORATION**

PROJECT WESTLINE SITE — BORING NO MW013
PROJECT NO 473Y — DATE 7-7-87 — DRILLER [illegible] ERICSON
ELEVATION — FIELD GEOLOGIST SJ CONTI
WATER LEVEL DATA
(Date, Time & Conditions)

SAMPLE NO & TYPE OR RQD	DEPTH (Ft.) OR RUN NO	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth/Ft) OR SCREEN INT	SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS (HNU)
S-6	25.0	6 / 17	1.1/1.5		DENSE	OLIVE BLUE	SILTY SAND - SOME	GM	WET 0PPM
	26.5	30				GRAY	GRAVEL - TR CLAY		C.S. IS FRIABLE FIRST CHANGE IN
							TR. SS FRAG		COLOR. NOT ENOUGH CLAY TO BE CONFINING
									NOTE: MAY SET ZONE 2
7/7	30.0					MOTTLED			CASING @ 28'
7/8 S-7		17 / 27	1.4/1.5		V.DENSE	[illegible]	SILTY SAND - SOME GRAVEL	SM/	MOIST → WET (0PPM)
	31.5	36				[illegible]	[illegible]	GM	[illegible]
							TR CLAY		[illegible] SUBROUNDED GRAVEL
									NOT ENOUGH CLAY - BUT MAY BE SEMI-CON-
	35.0								FINING.
S-8	35.9	30 / 50/.4	0.7/0.9		V.DENSE	BLUE GRAY	SILTY F. TO C. SAND -	SM/	MOIST → WET (0PPM)
							SOME GRAVEL	GM	V.SL.TR CLAY - LESS
							TR. SS FRAG		THAN S-7 1" D FRAG - MORE
									[illegible] THAN ABOVE
	40.0					BLUE			POSSIBLE 35 TO 45 SCREEN LOC. SQUEEZED
S-9		31 / 34	1.2/1.5		V.DENSE	BRN GRAY	SILTY SAND (FINE TO M.)	SM	HOLDS TOGETHER WHEN MOIST → WET (0PPM)
	41.5	24					SOME GRAVEL TR	/GM	LITTLE MORE CLAY THAN
							CLAY		S-8 SUBROUNDED GRAVEL
									VERY SLOW DRILLING 40-45 (RIG STALLS)
	45.0					BLUE			LESS CLAY LAST 3" OF SAMPLE
S-10		13 / 34	1.2/1.5		V.DENSE	BRN GRAY	SILTY SAND (FINE TO M.)	SM	MOIST → WET (0PPM)
	46.5	50					SOME GRAVEL - TR	/GM	1" Ø SIZE - HOLDS TO- GETHER WHEN SQUEEZED
							CLAY		BUT NOT COHESIVE CLASS- IFICATION
									[illegible] DRILLING TO 50'

REMARKS S-6 @ 4:40 PM
S-8 @ 8:36 AM 7-8-87
S-10 @ 10:40 AM S-11 [illegible]

BORING MW013

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BORING LOG NUS CORPORATION

PROJECT WESTLINE SITE
PROJECT NO 473Y
ELEVATION
WATER LEVEL DATA
(Date, Time & Conditions)

DATE 7-8-87
FIELD GEOLOGIST SJ Conti

BORING NO MW 013
DRILLER E. Ericsson

	SAMPLE NO & TYPE OR RQD	DEPTH (FT) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft) OR SCREEN INT	SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
	S-11	50.0	15 / 41	1.0/1.3		V. DENSE	MOTTLED BUFF	SILTY SAND - SOME GR	GM/	MOIST - (OPPM)
		51.3	50/3				BRN GRAY	TR CLAY	SM	MOTTLED W/ PCS OF BLACK COAL/LIGNITE
										MORE CLAY THAN ABOVE PORTIONS OF SAMPLE - COHESIVE CLASSIF.
		55.0			55.0					
	S-12		11 / 15	1.1/1.5		V. STIFF TO STIFF	GRAY ORANG BRN	SANDY CLAY / CLAYEY SAND SOME GRAVEL	SC	MOIST → WET (OPPM)
		56.5	26							NOTE COLOR CHANGE ALSO - MORE CLAY THAN ANY SAMPLE - SUBROUNDED GRAINS
										FIRST COHESIVE TYPE CLASSIF.
		60.0	40							
	S-13	60.9	50/.4	0.7/0.9		V. DENSE	ORANG BRN	SANDY CLAY/ CLAYEY SAND - SOME GRAVEL	SC/ GW	MOIST → WET (OPPM)
										NOT AS MUCH CLAY AS S-12 BUT VERY COMPACT. SUBROUNDED GRAINS
										SET CAS. @ 62'.
		65.0								
7/13	S-14	65.8	37 / 50/.3	0.7/0.8		V. DENSE	BRN ORANG	SILTY SAND - SOME GR AND ROCK FRAG - TR. CLAY	SM/ GW	MOIST (OPPM)
										MORE CLAY TOWARDS TOP OF SAMPLE MAX 3/4' ⌀ SIZE
					68.0		YELLOW BRN			COLOR CHANGE AT ≈68' MORE SAND PER DRILLER - BOTTOM OF SEMI CONF LAYER ?
		70.0								
7/14	S-15		39 / 39	1.0/1.5		V. DENSE	YELLOW BRN	CLAYEY SAND (F. TO C) SOME GRAVEL - TR ROCK FRAG.	SC/ GC	MOIST → WET (OPPM)
		71.5	41							1" MAX GRAVEL
										MORE GRAVEL @ 72' PER DRILLER

REMARKS Using hollow stem to advance boring - washing out thru augers, when needed, to obtain sample
S-12 @ 1:46 PM
S-13 → 3.32 PM - LOGGED IN BY 3 47 PM
SET 6" ⌀ STEEL CASING TO 62' - WILL DRILL BELOW CASING AFTER GROUT SETS UP. S-14 @ 3 20 PM 7-13-87
S-15 @ 7:57 AM 7-14-87

BORING MW 013

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D334901

BORING LOG — **NUS CORPORATION**

PROJECT WESTLINE SITE — BORING NO MW013
PROJECT NO. 437Y — DATE 7-13-87 / 7-14-87 — DRILLER B. ERICSON
ELEVATION — FIELD GEOLOGIST SJ CONTI
WATER LEVEL DATA
(Date, Time & Conditions)

SAMPLE NO. & TYPE OR RQD	DEPTH (Ft) OR RUN NO	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft) OR SCR	SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS (HNU)
S-16	75.0	28 / 50/.5	0.9/1.0	75	V. DENSE	GRAY ORANG BRN	FINE TO C. CLAYEY SAND - SOME	SC	WET (OPPM)
	76.0						GRAVEL - TR		NOT AS MUCH CLAY AS S-15 - BOTM OF
							ROCK FRAG (S.S.)		SAMPLE BECOMES MORE SANDY
									MAX 1" Ø RC.
	80.0								NO SAMPLE @ 80' -
									DECIDED TO GO TO 85'.
	85.0	50/.4	0.4/0.4		V. DENSE	GRAY ORANG	SILTY F. TO C SAND - SOME	GW	WET (OPPM)
S-17	85.4			85		BRN	GRAVEL - TR		SUBROUNDED GRAINS
							S.S. FRAG - TR		V. SL TR CLAY - WILL
							CLAY		SET SCREEN ≈ 75' TO 85' IN THIS
									BORING.
							BOTM OF HOLE @ 85.0'		

REMARKS S-17 @ 2:20 PM 7-14-87 - METHOD BEHIND 6" CASING SPUN 4" Ø - 5⅞" OD CASING TO BOTM. USING WATER AS DRILLING FLUID

BORING MW 013
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D334901

NUS CORPORATION ENVIRONMENTAL MANAGEMENT GROUP	STANDARD OPERATING PROCEDURES	Number GH-1.6	Page 1 of 3
		Effective Date 05/04/90	Revision 2
		Applicability EMG	
		Prepared Earth Sciences	
Subject	DECONTAMINATION OF DRILLING RIGS AND MONITORING WELL MATERIALS	Approved D. Senovich	

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1.0 PURPOSE

2.0 SCOPE

3.0 GLOSSARY

4.0 RESPONSIBILITIES

5.0 PROCEDURES

6.0 RECORDS

1.0 PURPOSE

The purpose of this procedure is to provide reference information regarding the appropriate procedures to be followed when conducting decontamination activities of drilling equipment and monitoring well materials used during field investigations.

2.0 SCOPE

This procedure addresses only drilling equipment and monitoring well materials decontamination, and shall not be considered for use with chemical sampling and field analytical equipment decontamination.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

Field Operations Leader - Responsible for ensuring that project specific plans and the implementation f field investigations are in compliance with these procedures.

5.0 PROCEDURES

To insure that analytical chemical results are reflective of the actual concentrations present at sampling locations, various drilling equipment involved in field investigations must be pr perly decontaminated. This will minimize the potential for cross-contamination between sampling locati ns, and the transfer of contamination off site.

Prior to the initiation of a drilling program. all drilling equipment involved in field sampling activities shall be decontaminated by steam cleaning at a predetermined area. The steam cleaning pr cedure shall be performed using a high-pressure spray of heated potable water producing a pressurized stream of steam. This steam shall be sprayed directly onto all surfaces of the various equipment which might contact environmental sample. The decontamination procedure shall be performed until all equipment is free of all visible potential contamination (dirt, grease, oil, noticeable odors, etc.) In addition, this decontamination procedure shall be performed at the completion of each sampling and/or drilling location, including soil borings, installation of monitoring wells, test pits, etc. Such equipment shall include drilling rigs, backhoes, downhole tools, augers, well casings, and screens.

The steam cleaning area shall be designed to contain decontamination wastes and waste waters, and can be a lined excavated pit or a bermed concrete or asphalt pad. For the latter, a floor drain must be provided which is connected to a holding facility. A shallow above-surface tank may be used or a pumping system with discharge to a waste tank may be installed.

In certain cases, due to budget constraints, such an elaborate decontamination pad is not possible. In such cases, a plastic lined gravel bed pad with a collection system may serve as an adequate decontamination area. The location of the steam cleaning area shall be on site in order to minimize potential impacts at certain sites.

Guidance to be used when decontaminating equipment shall include:

- As a general rule, any part of the drilling rig which extends over the borehole, shall be steam cleaned.
- All drilling rods, augers, and any other equipment which will be introduced to the hole shall be steam cleaned.
- The drilling rig, all rods and augers, and any other potentially contaminated equipment shall be decontaminated between each well location to prevent cross contamination of potential hazardous substances.

Rinsate samples of well casing and screens may be necessary if specifically required for a given site. If required, at least 1 percent, and no more than 5 percent of steam cleaned lengths of casing and screens combined shall be sampled.

Prior to leaving at the end of each work day and/or at the completion of the drilling program, drilling rigs and transport vehicles used onsite for personnel or equipment transfer shall be steam cleaned. A drilling rig left at the drilling location does not need to be steam cleaned until it is finished drilling at that location.

6.0 RECORDS

None.

NUS CORPORATION ENVIRONMENTAL MANAGEMENT GROUP	STANDARD OPERATING PROCEDURES	Number GH-1.7	Page 1 of 17
		Effective Date 05/04/90	Revision 1
		Applicability EMG	
		Prepared Earth Sciences	
Subject GROUNDWATER MONITORING POINT INSTALLATION		Approved D. Senovich	

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- 5.3.3 Bedrock Monitoring Wells
- 5.3.4 Drive Points
- 5.3.5 Innovative Monitoring Well Installation Techniques
- 5.4 WELL DEVELOPMENT METHODS

6.0 REFERENCES

7.0 RECORDS

1.0 PURPOSE

This procedure describes methods for proper monitoring well design, installation, and development.

2.0 SCOPE

This procedure is applicable to the construction of permanent monitoring wells at hazardous waste sites. The methods described herein may be modified by project-specific requirements for monitoring well construction. In addition, many regulatory agencies have specific regulations pertaining to monitoring well construction and permitting. These requirements must be ascertained during the development of the investigation and any required permits which may have to be obtained before field work begins. Innovative monitoring well installation techniques, which typically are not used, will be discussed only generally in this procedure.

3.0 GLOSSARY

Monitoring Well - A well which is properly screened (if screening is necessary), cased, and sealed which is capable of providing a groundwater level and groundwater sample representative of the zone being monitored.

Pi zometer - A pipe or tube inserted into the water bearing zone, typically open to water flow at the bottom and to the atmosphere at the top, and used to measure water level elevations. Piezometers may range in size from 1/2-inch diameter plastic tubes to well points or monitoring wells.

Potentiometric Surface - The surface to which water in an aquifer would rise by hydrostatic pressure.

Well Point (Drive Point) - A screened or perforated tube (Typically 1-1/4 or 2 inches in diameter) with a s lid, conical, hardened point at one end, which is attached to a riser pipe and driven into the ground with a sledge hammer, drop weight, or mechanical vibrator. Well points may be used for groundwater injection and recovery, as piezometers (i.e., to measure water levels) or to provide groundwater samples for water quality data.

4.0 RESPONSIBILITIES

Driller - The driller provides adequate and operable equipment, sufficient quantities of materials, and an experienced and efficient labor force to perform all phases of proper monitoring well installation and construction. He may also be responsible for obtaining, in advance, any required permits f r monitoring well installation and construction.

Rig Geologist - The rig geologist supervises well installation and construction by the Driller, documents all phases of well installation and construction, and insures that well construction is adequate to provide representative ground water data from the monitored interval. Geotechnical engineers, field technicians, or other suitable trained personnel may also serve in this capacity.

5.0 PROCEDURES

5.1 EQUIPMENT/ITEMS NEEDED

Below is a list of items that may be needed while installing a monitoring well.

- Health and safety equipment as required by the site safety officer.
- Well drilling and installation equipment with associated materials (typically supplied by the driller).

  Hydrogeologic equipment (weighted engineers tape, water level indicator, retractable engineers rule electronic calculator, clipboard, mirror and flashlight - for observing downhole activities, paint and ink marker for marking monitoring wells, sample jars, well installation forms, and a field notebook).
- Drive point installations tools (Sledge Hammer, drop hammer, or mechanical vibrator; tripod, pipe wrenches, drive points, riser pipe, and end caps).

5.2 WELL DESIGN

The objectives for each monitoring well and its intended use must be clearly defined before the m nitoring system is designed. Within the monitoring system, different monitoring wells may serve different purposes and, therefore, require different types of construction. During all phases of the well design, attention must be given to clearly documenting the basis for design decisions, the details f well construction, and the materials to be used. The objectives for installing the monitoring wells may include:

Determining groundwater flow directions and velocities.
Sampling or monitoring for trace contaminants.
Determining aquifer characteristics (e.g., hydraulic conductivity)

Siting of monitoring wells shall be performed after a preliminary estimation of the groundwater flow direction. In most cases, these can be determined through the review of geologic data and the site t rrain. In addition, production wells or other monitoring wells in the area may be used to determine the gr undwater flow direction. If these methods cannot be used, piezometers, which are relatively inexpensive to install, may have to be installed in a preliminary phase to determine groundwater flow direction.

5.2.1 Well Depth, Diameter, and Monitored Interval

The well depth, diameter, and monitored internal must be tailored to the specific monitoring needs of each investigation. Specification of these items generally depends on the purpose of the m nitoring system and the characteristics of the hydrogeologic system being monitored. Wells of different depth, diameter, and monitored interval can be employed in the same groundwater monitoring system. For instance, varying the monitored interval in several wells, at the same location (cluster wells) can help to determine the vertical gradient and the levels at which contaminants are present. Conversly, a fully penetrating well is usually not used to quantify or vertically locate a c ntamination plume, since groundwater samples collected in wells that are screened over the full thickness of the water bearing z ne will be representative of average conditions across th entire monitored interval. However, fully penetrating wells can be used to stablish the existence of contamination in water bearing zone. The well diameter would depend upon the hydraulic characteristics of the water bearing zone Sampling requirements, drilling method and cost.

The decision concerning the monitored interval and well depth is based on the following information:

- The vertical location of the contaminant source in relation to the water bearing zone.
- The depth, thickness and uniformity of the water bearing zone.
- The anticipated depth, thickness, and characteristics (e.g., density relative to water) of the contaminant plume.
- Fluctuation in groundwater levels (due to pumping, tidal influences, or natural recharge/discharge events).
- The presence and location of contaminants encountered during drilling.
- Whether the purpose of the installation is for determining existence or non-existence of contamination or if a particular stratigraphic zone is being investigated.
- The analysis of borehole geophysical logs.

In most situations where groundwater flow lines are horizontal, depending on the purpose of the well and the site conditions, monitored intervals are 20 feet or less. Shorter screen lengths (1 to 2 feet) are usually required where flow lines are not horizontal, (ie., if the wells are to be us d f r accurate measurement of the potentiometric head at a specific point).

Many factors influence the diameter of a monitoring well. The diameter of the monitoring w ll depends on the application. In determining well diameter, the following needs must be considered:

- Adequate water volume for sampling.
- Drilling methodology.
- Type of sampling device to be used.
- Costs

Standard monitoring well diameters are 2, 4, 6, or 8 inches. However, drive points are typically 1-1/4 or 2 inches in diameter. For monitoring programs which require screened monitoring w lls, either a 2-inch or 4-inch diameter well is preferred. Typically, well diameters greater than 4 inches ar used in monitoring programs in which open hole monitoring wells are required. In the smaller diameter wells, the volume of stagnant water in the well is minimized, and well construction costs are reduced, however, the type of sampling devices that can be used are limited. In specifying well diameter, sampling requirements must be considered. Up to a total of 4 gallons of water may be required for a single sample to account for full organic and inorganic analyses, and split samples. The water in the monitoring well available for sampling is dependent on the well diameter as follows:

Casing Inside Diameter, Inch	Standing Water Depth to Obtain 1 Gal Water (feet)	Total Depth of Standing Water for 4 Gal. (feet)
2	6 13	25
4	1.53	6
6	0.68	3

However, if a specific well recharges quickly after purging, then well diameter may not be an important factor regarding sample volume requirements.

Pumping tests for determining aquifer characteristics may require larger diameter wells; however, in small diameter wells.in-situ permeability tests can be performed during drilling or after well installation is completed.

5.2.2 Riser Pipe and Screen Materials

Well materials are specified by diameter, type of material, and thickness of pipe. Well screens requir an additional specification of slot size. Thickness of pipe is referred to as "schedule" for polyvinyl chloride (PVC) casing and is usually Schedule 40 (thinner wall) or 80 (thicker wall). Steel pipe thickness is often referred to as "Strength" and Standard Strength is usually adequate for monitoring well purposes. With larger diameter pipe, the wall thickness must be greater to maintain adequate strength. The required thickness is also dependent on the method of installation;-risers for drive points require greater strength than wells installed inside drilled borings.

The selection of well screen and riser materials depends on the method of drilling, the type of subsurface materials in which the well penetrates, the type of contamination expected, and natural water quality and depth. Cost and the level of accuracy required are also important. The materials generally available are Teflon, stainless steel, PVC, galvanized steel, and carbon steel. Each has advantages and limitations (see Attachment A of this guideline for an extensive discussion on this topic). The two most commonly used materials are PVC and stainless steel for wells in which screens are installed and are compared in Attachment B. Stainless steel is preferred where trace metals r organic sampling is required; however, costs are high. Teflon materials are extremely expensive, but are relatively inert and provide the least opportunity for water contamination due to well materials. PVC has many advantages, including low cost, excellent availability, light weight, and ease of manipulation; however, there are also some questions about organic chemical sorption and leaching that are currently being researched (see Barcelona et al., 1983). Concern about the use of PVC can be minimized if PVC wells are used strictly for geohydrologic measurements and not for chemical sampling. The crushing strength of PVC may limit the depth of installation, but schedule 80 materials normally used for wells greater than 50 feet deep may overcome some of the problems associated with depth. However, the smaller inside diameter of Schedule 80 pipe may be an important factor when considering the size of bailers or pumps to be used for sampling or testing. Due to this problem, the minimum well pipe size recommended for schedule 80 wells is 4 inch I.D.

Screens and risers may have to be decontaminated before use because oil-based preservatives and oil used during thread cutting and screen manufacturing may contaminate samples. Metal pipe, may corrode and release metal ions r chemically react with organic constituents, but this is considered by some to be less f a pr blem than the problem associated with PVC material. Galvanized steel is not recomm nded for metal analyses, as zinc and cadmium levels in gr undwater samples may be elevated from the zinc coating.

Threaded, flush-joint casing is most often preferred for monitoring well applications. PVC, Teflon, and steel can all be obtained with threaded joints at slightly more costs. Welded-joint steel casing is also acceptable Glued PVC may release organic contamination into the well and therefore should not be used if the well is to be sampled for organic contaminants.

When the water bearing zone is in consolidated bedrock, such as limestone or fractured granite, a well screen is often not necessary (the well is simply an open hole in bedrock). Unconsolidated materials, such as sands, clay, and silts require a screen. A screen slot size of 0.010 or 0.020 inch is generally used when a screen is necessary and the screened interval is artificially packed with a fine sand. The slot size controls the quantity of water entering the well and prevents entry of natural materials or sand pack. The screen shall pass no more than 10 percent of the pack material, or in-situ aquifer material. The rig geologist shall specify the combination of screen slot size and sand pack which will be compatible with the water bearing zone, to maximize groundwater inflow and minimize head losses and movement of fines into the wells. (For example, as a standard procedure, a Morie No. 1 or Ottowa sand may be used with a 0.010-inch slot screen, however, with a 0.020-inch sl t screen, the filter pack material must be the material retained on a No. 20 to No. 30 U.S. standard sieve.)

5.2.3 Annular Materials

Materials placed in the annular space between the borehole and riser pipe and screen include a sand pack when necessary, a bentonite seal, and cement-bentonite grout. The sand pack is usually a fine to medium grained well graded, silica sand. The quantity of sand placed in the annular space is dependent upon the length of the screened interval but should always extend at least 1 foot above the top of the screen. At least one to three feet of bentonite pellets or equivalent shall be placed above the sand pack. The cement-bentonite grout or equivalent extends from the top of the bentonite pellets to the ground surface.

On occasion, and with the concurrence of the involved regulatory agencies, monitoring wells may be packed naturally, i.e., no artificial sand pack will be installed, and the natural formation material will be allowed to collapse around the well screen after the well is installed. This method has been utilized where the formation material itself is a relatively uniform grain size, or when artificial sand packing is not possible due to borehole collapse.

Bent nite expands by absorbing water and provides a seal between the screened interval and the overlying portion of the annular space and formation. Cement-bentonite grout is placed on top of the bentonite pellets to the surface. The grout effectively seals the well and eliminates the possibility for surface infiltration reaching the screened interval. Grouting also replaces material removed during drilling and prevents hole collapse and subsidence around the well. A tremie pipe should be used to introduce grout from the bottom of the hole upward, to prevent bridging and to provide a better seal. However, in boreholes that don't collapse, it may be more practical to pour the gr ut from the surface without a tremie pipe.

Grout is a general term which has several different connotations. For all practical purposes within the monitoring well installation industry, grout refers to the solidified material which is installed and occupies the annular space above the bentonite pellet seal. Grout, most of the time, is made up of two assemblages of material, i.e., a cement-bentonite grout. A cement bentonite grout normally is a mixture of cement, bentonite and water at a ratio of one 90-p und bag of Portland Type I cement, 3-5 pounds of granular or flake-type bentonite and 6 gallons of water. A neat cement is made up of one ninety-pound bag of Portland Typ I cement and 6 gallons of water.

In certain cases, the borehole may be drilled to a depth greater than the anticipated well installation depth. For these cases, the well shall be backfilled to the desired depth with bentonite pellets or equivalent. A short (1'-2') section of capped riser pipe sump is sometimes installed immediately below the screen, as a silt reservoir, when significant post-development silting is anticipated. This will ensure that the entire screen surface remains unobstructed.

5.2.4 Protective Casing

When the well is completed and grouted to the surface, a protective steel casing is often placed over the top for the well. This casing generally has a hinged cap and can be locked to prevent vandalism. A vent hole shall be provided in the cap to allow venting of gases and maintain atmospheric pressure as water levels rise or fall in the well. The protective casing has a larger diameter than the well and is set into the wet cement grout over the well upon completion. In addition, one hole is drilled just above the cement collar through the protective casing which acts as a weep hole for the flow of water which may enter the annulus during well development, purging, or sampling.

A Protective casing which is level with the ground surface is used in roadway or parking lot applications where the top of a monitoring well must be below the pavement. The top of the riser pipe is placed 4 to 5 inches below the pavement, and a locking protective casing is cemented in place to 3 inches below the pavement. A large diameter protective sleeve is set into the wet cement around the well with the top set level with the pavement. A manhole type lid placed over the protective sleeve. The cement should be slightly mounded to direct pooled water away from the well head.

5.3 MONITORING WELL INSTALLATION

5.3.1 Monitoring Wells in Unconsolidated Sediments

After the borehole is drilled to the desired depth, well installation can begin. The procedure for well installation will partially be dictated by the stability of the formation in which the well is being placed. If the borehole collapses immediately after the drilling tools are withdrawn, then a temporary casing must be installed and well installation will proceed through the center of the temporary casing, and continue as the temporary casing is withdrawn from the borehole. In the case f holl w stem auger drilling, the augers will act to stabilize the borehole during well installation.

Bef re the screen and riser pipe are lowered into the borehole, all pipe and screen sections should be measured with an engineers rule to ensure proper well placement. When measuring sections, the threads on one end of the pipe or screen must be excluded while measuring, since the pipe and screen sections are screwed flush together.

After the screen and riser pipe are lowered through the temporary casing, then the sand pack can be installed. A weighted tape measure must be used during the procedure in order to carefully m nitor installation progress. The sand is poured into the annulus between the riser pipe and temporary casing, as the casing is withdrawn. Sand should always be kept within the temporary casing during withdrawal in order to ensure an adequate sand pack. However, if too much sand is within the temporary casing (greater than 1 foot above the bottom of the casing) bridging between the temporary casing and riser pipe may occur.

After the sand pack is installed to the desired depth, (at least 1 foot above the top of the screen) then the bentonite pellet seal or equivalent, can be installed, in the same manner as the sand pack. At least 1 to 3 feet of b ntonite pellets should be installed above the sand pack.

The cement-bentonite grout is then mixed and either poured or tremied into the annulus as the temporary casing or augers are withdrawn. Finally, the protective casing can be installed as detailed in Section 5.2.4

In stable formations where borehole collapse does not occur, the well can be installed as discussed above, and the use of a temporary casing is not needed. However, centralizers may have to be installed, one above, and one below the screen, to assure enough annular space for sand pack placement. A typical overburden monitoring well sheet is shown.

5.3.2 Confining Layer Monitoring Wells

When drilling and installing a well in a confined aquifer, proper well installation techniques must be applied to avoid cross contamination between. Under most conditions, this can be accomplished by installing double-cased wells. This is accomplished by drilling a large diameter boring through the upper aquifer, 1 to 3 feet into the underlying confining layer, and setting and pressure grouting or tremie grouting the outer casing into the confining layer. The grout material must fill the space between the native material and the outer casing. A smaller diameter boring is then continued through the confining layer for installation of the monitoring well as detailed for overburd n monitoring wells, with the exception of not using a temporary casing during installation. Sufficient time which will be determined by the rig geologist, must be allowed for setting of the grout prior t drilling through the confined layer. A typical confining layer monitoring well sheet is shown in Attachment C.

5.3.3 Bedrock Monitoring Wells

When installing bedrock monitoring wells, a large diameter boring is drilled through the overburden and approximately 5 feet into the bedrock. A casing (typically steel) is installed and either pressure grouted or tremie grouted in place. After the grout is cured, a smaller diameter boring is continu d through the bedrock to the desired depth. If the boring does not collapse, the well can be left open, and a screen is not necessary. If the boring collapses, then a screen is required and can be installed as detailed for overburden monitoring wells. However, if a screen is to be used, then the casing which is installed through the overburden and into the bedrock does not require grouting and can be install d temporary until final well installation is completed. Typical well construction forms for bedrock monitoring wells are shown in Attachment C.

5.3.4 Drive Points

Drive points can be installed with either a sledge hammer, drop hammer, or a mechanical vibrator. The screen is threaded and tightened onto the riser pipe with pipe wrenches. The drive point is simply pounded into the subsurface to the desired depth. If a heavy drop hammer is used, then a tripod and pulley setup is required to lift the hammer. Drive points typically cannot be driven to depths exceeding 10 feet.

5.3.5 Innovative Monitoring Well Installation Techniques

Certain innovative sampling devices have proven advantageous. These devices are essentially screened samplers installed in a borehole with only one or two small-diameter tubes extending to the surface. Manufacturers of these types of samplers claim that four samplers can be installed in a 3-inch diameter borehole. This reduces drilling costs, decreases the volume of stagnant water, and provides a sampling system that minimizes cross contamination from sampling equipment. These sampl rs also perform well when the water table is within 25 feet from the surface (the typical range of suction pumps). Two manufacturers of these samplers are Timc Manufacturing Company, Inc., of

Prairie du Sac, Wisconsin, and BARCAD Systems, Inc., of Concord, Massachusetts Each offers various construction materials.

Two additional types of multilevel sampling systems have been developed. Both employ individual screened openings through a small-diameter casing. One of these systems (marketed by Westbay Instruments Ltd. of Vancouver, British Columbia, Canada) uses a screened port and a sampling probe to obtain samples and head measurements or perform permeability tests. this system allows sampling ports at intervals as close as 5 feet, if desired, in boreholes from 3 to 4.8 inches in diameter

The other system, developed at the University of Waterloo at Waterloo, Ontario, Canada, requires field assembly of the individual sampling ports and tubes that actuate a simple piston pump and force the samples to the surface. Where the depth to ground water is less than 25 feet, the piston pumps are not required. The assembly is made of easily obtained materials; however, the cost of labor to assemble these monitoring systems may not be cost-effective.

5.4 WELL DEVELOPMENT METHODS

The purpose of well development is to stabilize and increase the permeability of the gravel pack around the well screen, and to restore the permeability of the formation which may have be n reduced by drilling operations. Wells are typically developed until all fine material and drilling water is removed from the well. Sequential measurements of pH, conductivity and temperature taken during development may yield information (stabilized values) that sufficient development is reached. The selection of the well development method (shall) be made by the rig geologist and is based on the drilling methods, well construction and installation details, and the characteristics of the formation that the well is screened in. The primary methods of well development are summarized below. A more detailed discussion may be found in Driscoll (1986).

Overpumping and Backwashing - Wells may be developed by alternatively drawing the water level down at a high rate (by pumping or bailing) and then reversing the flow direction (backwashing) s that water is passing from the well into the formation. This back and forth movement of water through the well screen and gravel pack serves to remove fines from the formation immediately adjacent to the well, while preventing bridging (wedging) of sand grains. Backwashing can be accomplished by several methods including pouring water into the well and then bailing, starting and stopping a pump intermittently to change water levels, or forcing water into the well under pressure thr ugh a water-tight fitting ("rawhiding"). Care should be taken when backwashing not to apply t o much pressure, which could damage or destroy the well screen.

Surging with a Surge Plunger - A surge plunger (also called a surge block) is approximately the same diameter as the well casing and is used to agitate the water, causing it to move in and out of the screens. This movement of water rpulls fine materials into the well, where they may be removed by any of several methods, and prevents bridging of sand particles in the gravel pack. There are tw basic types of surge plungers; solid and valved surge plungers. In formations with low yields, a valved surge plunger may be preferred, as solid plungers tend to force water out of the well at a greater rate than it will flow back in. Valved plungers are designed to produce a greater inflow than outflow of water during surging.

Compressed Air - Compressed air can be used to develop a well by either of two methods: backwashing or surging. Backwashing is done by forcing water out through the screens, using increasing air pressure inside a sealed well, then releasing the pressurized air t allow the water to flow back int the well. Care should be taken when using this method so that the water level do s not drop below the top f the screen, thus reducing well yield. Surging, or the "open well" method, consists of alternately releasing large volumes of air suddenly into an open well below the water level to produce a strong surge by virtue of the resistance of water head, friction, and inertia. Pumping the well is subsequently done with the air lift method.

High Velocity Jetting - In the high velocity jetting method, water is forced at high velocities from a plunger-type device and through the well screen to loosen fine particles from the sand pack and surrounding formation The jetting tool is slowly rotated and raised and lowered along the length of the well screen to develop the entire screened area. Jetting using a hose lowered into the well may also be effective. The fines washed into the screen during this process can then be bailed or pumped from the well.

6.0 REFERENCES

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Barcelona, M. J., P. P Gibb and R. A. Miller, 1983. A Guide to the selection of Materials for Monitoring Well Construction and Groundwater Sampling. ISWS Contract Report 327, Illinois State Water Surv y, Champaign, Illinois.

U.S. EPA, 1980. Procedures Manual for Groundwater Monitoring of Solid Waste Disposal Facilities. Publication SW-611, Office of Solid Waste, U.S. EPA, Washington, D.C.

Driscoll, Fletcher G., 1986. Groundwater and Wells. Johnson Division, St. Paul, Minnesota, 1989 p.

7.0 RECORDS

A critical part of monitoring well installation is recording of significant details and events in the field notebook. The Geologist must record the exact depths of significant hydrogeological features screen placement, gravel pack placement, and bentonite placement.

A Monitoring Well Sheet (Attachment C) shall be used which allows the uniform recording of data for each installation and rapid identification of missing information. Well depth, length, mat rials of construction, length and openings of screen, length and type of riser, and depth and typ of all backfill materials shall be recorded. Additional information (shall) include location, installation date, problems encountered, water levels before and after well installation, cross-reference to the g ologic b ring log, and methods used during the installation and development process. The documentation is very important to prevent problems involving questionable sample validity. Somewhat different information will need to be recorded.depending on whether the well is completed in overburden, in a confined layer, in bedrock with a cased well, or as an open hole in bedrock.

The quantities of sand, bentonite, and grout placed in the well are also important. The Geologist shall calculate the annular space volume and have a general idea of the quantity of material needed to fill the annular space. Volumes of backfill significantly higher than the calculated volume may indicate a problem such as a large cavity, while a smaller backfill volume may indicate a cave-in. Any problems with rig operation or down time shall be recorded and may determine the driller's final fee.

ATTACHMENT A

TABLE 7-4 RELATIVE COMPATIBILITY OF RIGID WELL-CASING MATERIAL (PERCENT)

	PVC 1	Galvanized Steel	Carbon Steel	Lo-carbon Steel	Stainless steel 304	Stainless steel 316	Teflon*
Buffered Weak Acid	100	56	51	59	97	100	100
Weak Acid	98	59	43	47	96	100	100
Miner Acid/High Solids	100	48	57	60	80	82	100
Aqueous/Organic Mixtures	64	69	73	73	98	100	100
Percent Overall Rating	91	58	56	59	93	96	100

Preliminary Ranking of Rigid Materials

1 Teflon®
2 Stainless Steel 316
3 Stainless Steel 304
4 PVC 1
5 Lo-Carbon Steel
6 Galvanized Steel
7 Carbon Steel
* Trademark of DuPont

RELATIVE COMPATIBILITY OF SEMI-RIGID OR ELASTOMERIC MATERIALS (PERCENT)

	PVC Flexible	PP	PE Conv.	PE Linear	PMM	Viton®*	Silicone	Neoprene	Teflon®*
Buffered Weak Acid	97	97	100	97	90	92	87	85	100
Weak Acid	92	90	94	96	78	78	75	75	100
Mineral Acid/High Solids	100	100	100	100	95	100	78	82	100
Aqueous/Organic Mixtures	62	71	40	60	49	78	49	44	100
Percent Overall Rating	88	90	84	88	78	87	72	72	100

Preliminary Ranking of Semi-Rigid or Elastomeric Materials

1 Teflon®
2 Polypropylene (PP)
3 PVC flexible/PE linear
4 Viton®
5 PE Conventional
6 Plexiglas/Lucite (PMM)
7 Silicone/Neoprene
S urce: Barcelona et al., 1983
* Trademark of DuPont

ATTACHMENT B

COMPARISON OF STAINLESS STEEL AND PVC FOR MONITORING WELL CONSTRUCTION

Characteristic	Stainless Steel	PVC
Strength	Use in deep wells to prevent compression and closing of screen/riser.	Use when shear and compressive strength not critical.
Weight	Relatively heavier	Lightweight, floats in water
Cost	Relatively expensive	Relatively inexpensive
Corrosivity	Deteriorates more rapidly in corrosive water	Non-corrosive--may deteriorate in presence of ketones, aromatics, alkyl sulfides, or some chlorinated HC
Ease of Use	Difficult to adjust size or length in the field.	Easy to handle and work in the field.
Pr paration for Use	Should be steam-cleaned for organics sampling	Never use glue fittings--pipes should be threaded or pressure-fitted. Should be steam cleaned if used for monitoring wells.
Interaction with Contaminants*	May sorb organic or inorganic substances when oxidized	May sorb or release organic substances.

* See also Attachment A.

ATTACHMENT C

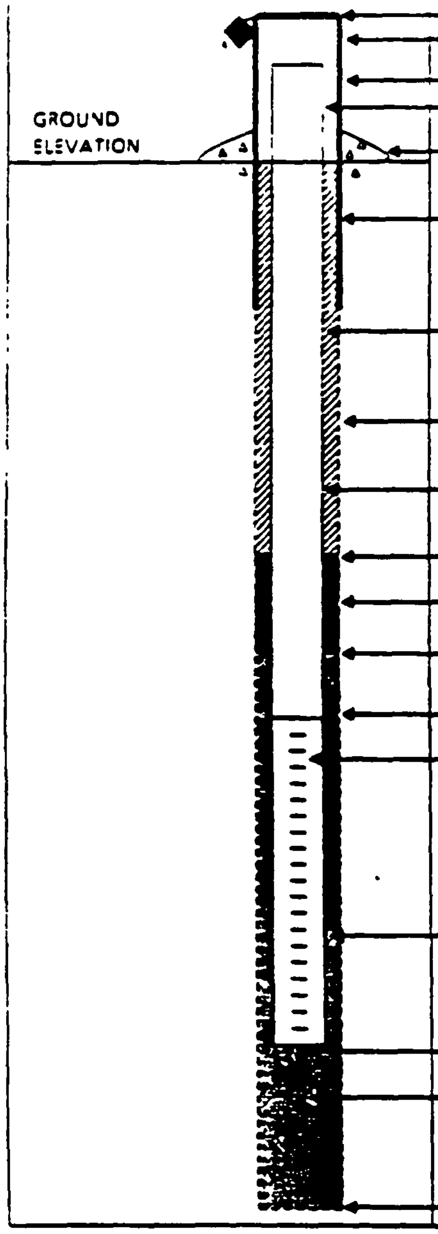
NUS CORPORATION
A Halliburton Company

BORING NO ________

OVERBURDEN MONITORING WELL SHEET

PROJECT ________ LOCATION ________
PROJECT NO ________ BORING ________
ELEVATION ________ DATE ________
FIELD GEOLOGIST ________

DRILLER ________
DRILLING METHOD ________
DEVELOPMENT METHOD ________



ELEVATION OF TOP OF SURFACE CASING ________
ELEVATION OF TOP OF RISER PIPE. ________
STICK - UP TOP OF SURFACE CASING. ________
STICK - UP RISER PIPE ________
TYPE OF SURFACE SEAL ________
I D OF SURFACE CASING: ________
TYPE OF SURFACE CASING ________
RISER PIPE I.D ________
TYPE OF RISER PIPE ________
BOREHOLE DIAMETER. ________
TYPE OF BACKFILL: ________
ELEVATION / DEPTH TOP OF SEAL: ________
TYPE OF SEAL: ________
DEPTH TOP OF SAND PACK. ________
ELEVATION / DEPTH TOP OF SCREEN: ________
TYPE OF SCREEN: ________
SLOT SIZE x LENGTH: ________
I D OF SCREEN: ________
TYPE OF SAND PACK: ________
ELEVATION / DEPTH BOTTOM OF SCREEN: ________
ELEVATION / DEPTH BOTTOM OF SAND PACK: ________
TYPE OF BACKFILL BELOW OBSERVATION WELL: ________
ELEVATION / DEPTH OF HOLE: ________

ATTACHMENT C
PAGE TWO

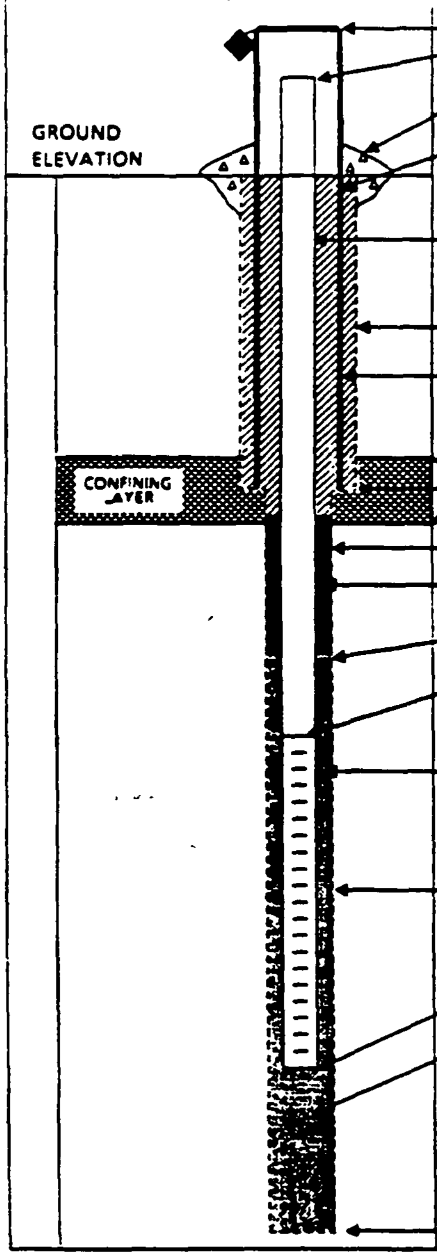
NUS CORPORATION

BORING NO ____________

CONFINING LAYER
MONITORING WELL SHEET

1 5 87

PROJECT ____________ LOCATION ____________ DRILLER ____________
PROJECT NO ____________ BORING ____________ DRILLING METHOD ____________
ELEVATION ____________ DATE ____________ DEVELOPMENT METHOD ____________
FIELD GEOLOGIST ____________



ELEVATION OF TOP OF PERM. CASING. ____________
ELEVATION OF TOP OF RISER PIPE ____________
TYPE OF SURFACE SEAL. ____________
I.D. OF PERM. CASING. ____________
TYPE OF SURFACE CASING: ____________
RISER PIPE I.D ____________
TYPE OF RISER PIPE. ____________
BOREHOLE DIAMETER. ____________
PERM. CASING I.D ____________
TYPE OF CASING & BACKFILL: ____________
ELEVATION / DEPTH TOP CONFINING LAYER: ____________
ELEVATION / DEPTH BOTTOM OF CASING: ____________
ELEVATION / DEPTH BOT. CONFINING LAYER: ____________
ELEVATION / DEPTH TOP OF SEAL: ____________
TYPE OF SEAL: ____________
DEPTH TOP OF SAND PACK: ____________
ELEVATION/DEPTH TOP OF SCREEN. ____________
TYPE OF SCREEN: ____________
TYPE OF SAND PACK: ____________
BOREHOLE DIA. BELOW CASING: ____________
ELEVATION / DEPTH BOTTOM OF SCREEN: ____________
ELEVATION / DEPTH BOTTOM OF SAND PACK ____________
TYPE OF BACKFILL BELOW OBSERVATION WELL: ____________
ELEVATION / DEPTH OF HOLE: ____________

ATTACHMENT C
PAGE THREE

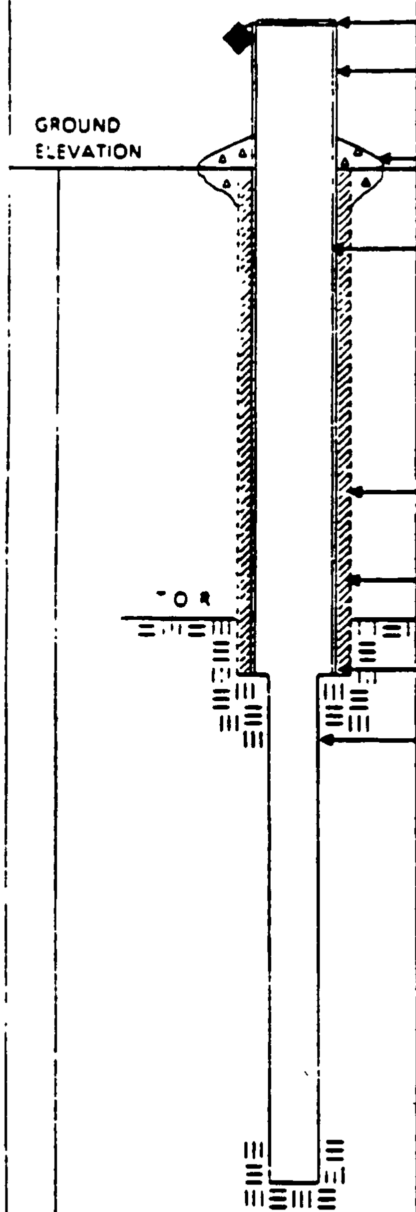
NUS CORPORATION
A Halliburton Company

BORING NO ________

BEDROCK
MONITORING WELL SHEET
OPEN HOLE WELL

PROJECT ________ LOCATION ________
PROJECT NO ________ BORING ________
ELEVATION ________ DATE ________
FIELD GEOLOGIST ________

DRILLER ________
DRILLING METHOD ________
DEVELOPMENT METHOD ________



ELEVATION OF TOP OF CASING: ________

STICK UP OF CASING ABOVE GROUND SURFACE: ________

TYPE OF SURFACE SEAL: ________

I.D. OF CASING: ________

TYPE OF CASING ________

TEMP / PERM ________

DIAMETER OF HOLE: ________

TYPE OF CASING SEAL ________

DEPTH TO TOP OF ROCK: ________

DEPTH TO BOTTOM CASING: ________

DIAMETER OF HOLE IN BEDROCK: ________

DESCRIBE IF CORE / REAMED WITH BIT:

____

____

____

DESCRIBE JOINTS IN BEDROCK AND DEPTH:

____

____

____

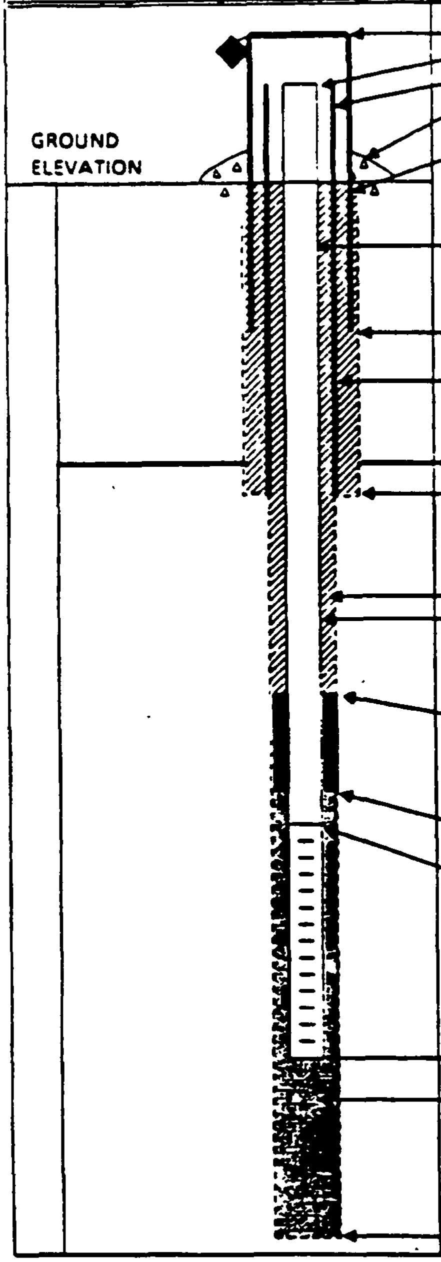
ELEVATION / DEPTH OF HOLE ________

ATTACHMENT C
PAGE FOUR

BORING NO ________

BEDROCK
MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

PROJECT ________ LOCATION ________ DRILLER ________
PROJECT NO ________ BORING ________ DRILLING METHOD ________
ELEVATION ________ DATE ________ DEVELOPMENT METHOD ________
FIELD GEOLOGIST ________



ELEVATION OF TOP OF SURFACE CASING ________
ELEVATION OF TOP OF RISER PIPE ________
ELEVATION TOP OF PERM CASING. ________
TYPE OF SURFACE SEAL: ________
I D OF SURFACE CASING. ________
TYPE OF SURFACE CASING. ________
RISER PIPE I D ________
TYPE OF RISER PIPE. ________
BOREHOLE DIAMETER: ________
PERM CASING I D ________
TYPE OF CASING & BACKFILL ________
ELEVATION / DEPTH TO BEDROCK ________
ELEVATION/DEPTH BOTTOM OF CASING ________
BOREHOLE DIA BELOW CASING ________
TYPE OF BACKFILL. ________
ELEVATION / DEPTH TOP OF SEAL: ________
TYPE OF SEAL: ________
ELEVATION / DEPTH TOP OF SAND PACK: ________
ELEVATION/DEPTH TOP OF SCREEN. ________
TYPE OF SCREEN: ________
TYPE OF SAND PACK. ________
ELEVATION / DEPTH BOTTOM OF SCREEN ________
ELEVATION / DEPTH BOTTOM OF SAND PACK ________
TYPE OF BACKFILL BELOW OBSERVATION WELL. ________
ELEVATION / DEPTH OF HOLE ________

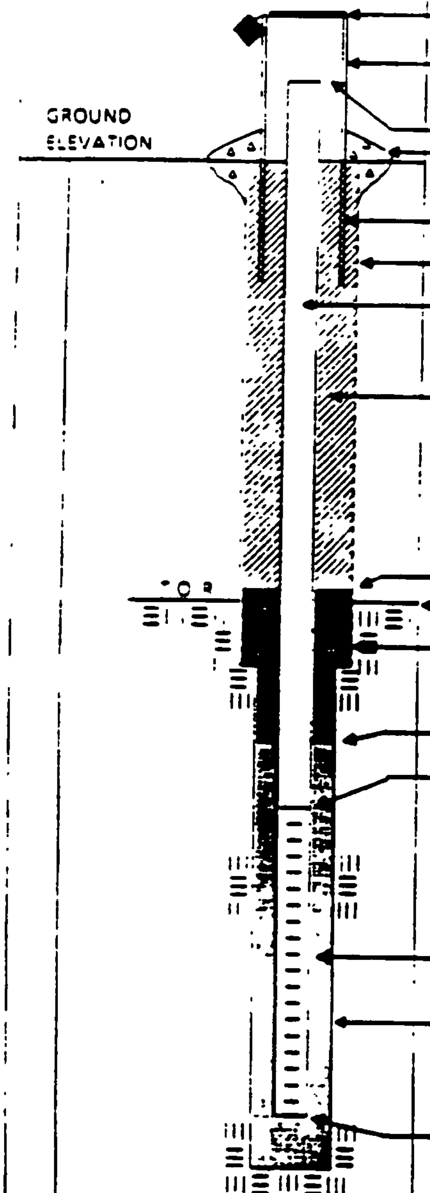
ATTACHMENT C
PAGE FIVE

NUS CORPORATION
A Halliburton Company

BORING NO ________

BEDROCK
MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

PROJECT ________ LOCATION ________ DRILLER ________
PROJECT NO ________ BORING ________ DRILLING
ELEVATION ________ DATE ________ METHOD ________
FIELD GEOLOGIST ________ DEVELOPMENT
METHOD ________



ELEVATION OF TOP OF SURFACE CASING ________

STICK UP OF CASING ABOVE GROUND SURFACE ________

ELEVATION TOP OF RISER ________

TYPE OF SURFACE SEAL ________
____

I.D. OF SURFACE CASING ________

DIAMETER OF HOLE ________

RISER PIPE I.D. ________

TYPE OF RISER PIPE ________
____

TYPE OF BACKFILL ________
____
____

ELEVATION / DEPTH TOP OF SEAL. ________

ELEVATION / DEPTH TOP OF BEDROCK ________

TYPE OF SEAL. ________
____

ELEVATION / DEPTH TOP OF SAND. ________

ELEVATION / DEPTH TOP OF SCREEN· ________

TYPE OF SCREEN· ________

SLOT SIZE x LENGTH ________

I.D. SCREEN· ________

TYPE OF SAND PACK. ________
____

DIAMETER OF HOLE IN BEDROCK·

CORE / REAM· ________
____

ELEVATION / DEPTH BOTTOM SCREEN: ________

ELEVATION / DEPTH BOTTOM OF HOLE ________

STANDARD OPERATING PROCEDURES

Number GH-2.5	Page 1 of 10
Effective Date 05/04/90	Revision 1
Applicability EMG	
Prepared Earth Sciences	
Approved D. Senovich	

Subject

WATER LEVEL MEASUREMENT/CONTOUR MAPPING

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1.0 PURPOSE

The objective of this procedure is to provide general reference information and technical guidance on the measurement of hydraulic head levels and the determination of the direction of groundwater flow, using contour maps of the water table or the potentiometric surface of an unconfined or confined aquifer.

2.0 SCOPE

This procedure gives overall technical guidance for obtaining hydraulic head measurements in wells (frequently conducted in conjunction with groundwater sampling) and preparation of groundwater contour maps. The specific methods could be modified by requirements of project-specific plans.

3.0 GLOSSARY

Hydraulic Head - The height to which water will rise in a well.

Water Table - A surface in an unconfined aquifer where groundwater pressure is equal to atmospheric pressure (i.e., the pressure head is zero).

Potentiometric Surface - A surface which is defined by the levels to which water will rise in w lls which are screened or open in a specified zone of an unconfined or confined aquifer.

Unconfined (water table) Aquifer - An aquifer in which the water table forms the upper boundary.

Confined Aquifer - An aquifer confined between two low permeability layers (aquitards).

Artesian Conditions - A common condition in a confined aquifer in which the water level in a well completed within the aquifer rises above the top of the aquifer.

Flow Net - A diagram of groundwater flow, showing flow lines and equipotential lines.

Flow Line - A line indicating the direction of groundwater movement within the saturated z n . Flow lines are drawn perpendicular to equipotential lines.

Equipotential Line - A contour line on the potentiometric surface or water table showing unif rm hydraulic head levels. Equipotential lines on the water table are also called water-table contour lines.

4.0 RESPONSIBILITIES

Project Hydrogeologist - has overall responsibility for obtaining water level measurements and developing groundwater contour maps. The hydrogeologist shall specify the reference point from which water levels are measured (usually a specific point on the upper edge of the inner well casing), the number of data points needed and which wells shall be used for a contour map, and how many c mplete sets of water levels are required to adequately define groundwater flow directions (e.g., if there are seasonal variations).

Fi ld Personnel - must have a basic familiarity with the equipment and procedures involved in obtaining wat r levels, and must be awar of any project-specific requirements.

5.0 PROCEDURES

5.1 GENERAL

Groundwater level measurements can be made in monitoring wells, private or public water wells, piezometers, open boreholes, or test pits (after stabilization). Groundwater measurements should generally not be made in boreholes with drilling rods or auger flights present. If groundwater sampling activities are to occur, groundwater level measurements shall take place prior to well evacuation or sampling.

All groundwater level measurements shall be made to the nearest 0.01 foot, and recorded in the geologist's field notebook or on the Groundwater Level Measurement Sheet (Attachment A), along with the date and time of the reading. The total depth of the well shall be measured and recorded, if not already known. Weather changes that occur over the period of time during which water levels ar being taken, such as precipitation and bariometric pressure changes, should be noted.

In measuring groundwater levels, there shall be a clearly-established reference point of known elevation, which is normally identified by a mark on the upper edge of the inner well casing. The reference point shall be noted in the field notebook. To be useful, the reference point should be tied in with an established USGS benchmark or other properly surveyed elevation datum. An arbitrary datum could be used for an isolated group of wells if necessary.

Cascading water within a borehole or steel well casings can cause false readings with some types of sounding devices (chalked line, electrical). Oil layers may also cause problems in determining the true water level in a well. Special devices (interface probes) are available for measuring the thickn ss of oil layers and true depth to groundwater if required.

Water level readings shall be taken regularly, as required by the site hydrogeologist. Monitoring w lls or open-cased boreholes that are subject to tidal fluctuations should be read in conjunction with a tidal chart (or preferably in conjunction with readings of a tide staff or tide level recorder installed in the adjacent water body); the frequency of such readings shall be established by the site hydrogeologist. All water level measurements at a site used to develop a groundwater contour map shall be made in the shortest practical time to minimize affects due weather changes, and at least during the same day.

5.2 WATER LEVEL MEASURING TECHNIQUES

There are several methods for determining standing or changing water levels in boreholes and monitoring wells. Certain methods have particular advantages and disadvantages depending upon well conditions. A general description of these methods is presented, along with a listing of various advantages and disadvantages of each technique. An effective technique shall be selected for the particular site conditions by the onsite hydrogeologist.

In most instances, preparation of accurate potentiometric surface requires that static water level measurements be obtained to a precision of 0.01 feet. To obtain such measurements in individual accessible wells, the Chalked Tape or Electrical Water Level Indicator methods have been found best, and thus are the most often utilized. Other, less precise methods, such as the Popper or Bell Sound or Bailer Line methods, may be appropriate for developing preliminary estimates of hydraulic conditi ns. When a large number of (or continuous) readings are required, time-consuming individual readings are not usually feasible. In such cases, it is best to use th Float Recorder or Pr ssure Transducer methods. When conditions in the well limit readings (i.e., turbulence in the water surface or limited access through small diameter tubing), less precise, but appropriate, methods such as the Air Line or Capillary Tubing methods can be used.

5.2.1 Methods

Water levels can be measured by several different techniques, but the same steps shall be followed in each case. The proper sequence is as follows:

1. Check operation of recording equipment above ground. Prior to opening the well, don personal protective equipment as required.

2. Record all information specified below in the geologist's field notebook or on the Groundwater Level Measurement Sheet.

    a. Well number.
    b. Record water level to the nearest 0.01 foot (0.3 cm). Water levels shall be taken from the surveyed reference mark on the top edge of the inner well casing.
    c. Record the time and day of the measurement.

Water level measuring devices with permanently marked intervals shall be used when possibl . If water level measuring devices marked by metal or plastic bands clamped at intervals along the measuring line are used, the spacing and accuracy of these bands shall be checked frequently as they may loosen and slide up or down the line, resulting in inaccurate reference points (see Section 5.2.3).

5.2.2 Water Level Measuring Devices

Chalked Steel Tape

The water level is measured by chalking a weighted steel tape and lowering it a known distance (to any convenient whole foot mark) into the well or borehole. The water level is determined by subtracting the wetted chalked mark from the total length lowered into the hole.

The tape shall be withdrawn quickly from the well because water has a tendency to rise up the chalk due to capillary action. A water finding paste may be used in place of chalk. The paste is spread on the tape the same way as the chalk, and turns red upon contacting water.

Disadvantages to this method include the following: depths are limited by the inconvenience of using heavier weights to properly tension longer tape lengths; ineffective if borehole/well wall is wet or inflow is occurring above the static water level; chalking the tape is time consuming; difficult to use during periods of precipitation.

Electric Water Level Indicators

These devices consist of a spool of small-diameter cable and a weighted probe attached to the end. When the probe comes in contact with the water, an electrical circuit is closed and a meter, light, and/or buzzer attached to the spool will signal the contact.

There are a number of commercial electric sounders available, none of which is entirely reliable under all conditions likely t occur in a contaminated monitoring w ll. In conditions where th re is oil on the water, groundwater with high specific conductance, water cascading int the well, steel well casing, r a turbulent wat r surface in the well, measuring with an electric sounder may be difficult

For accurate readings, the probe shall be lowered slowly into the well. The electric tape is marked at the measuring point where contact with the water surface was indicated. The distance from the mark to the nearest tape band is measured using an engineer's folding ruler or steel tape and added to the band reading to obtain the depth to water. If band is not a permanent marking band, spacing shall be checked periodically as described in Section 5.2.3.

Popper or Bell Sounder

A bell- or cup-shaped weight that is hollow on the bottom is attached to a measuring tape and lowered into the well. A "plopping" or "popping" sound is made when the weight strikes the surface of the water. An accurate reading can be determined by lifting and lowering the weight in short strokes, and reading the tape when the weight strikes the water. This method is not sufficiently accurate to obtain water levels to 0.01 feet, and thus is more appropriate for obtaining only approximate water levels quickly.

Float Recorder

A float or an electromechanically actuated water-seeking probe may be used to detect vertical changes of the water surface in the hole. A paper-covered recording chart drum is rotated by the up and down motion of the float via a pulley and reduction gear mechanism, while a clock drive moves a recording pen horizontally across the chart. To ensure continuous records, the recorder shall be inspected, maintained, and adjusted periodically. This type of device is useful for continuously measuring periodic water level fluctuations, such as tidal fluctuations or influences of pumping wells.

Air Line

An air line is especially useful in pumped wells where water turbulence may preclude the use of other devices. A small-diameter weighted tube of known length is installed from the surface to a depth below the lowest water level expected. Compressed air (from a compressor, bottled air, or air pump) is used to purge the water from the tube, until air begins to escape the lower end of the tube, and is seen (or heard) to be bubbling up through the water in the well. The pressure needed to purge the water from the air line multiplied by 2.307 (feet of water for 1 psi) equals the length in feet of submerged air line. The depth to water below the center of the pressure gauge can be calculated by subtracting the length of air line below the water surface from the total length of the air line.

The disadvantages to this method include the need for an air supply and lower level of accuracy (unless a very accurate air pressure gauge is used, this method cannot be used to obtain water level readings to the nearest 0.01 ft).

Capillary Tubing

In small diameter piezometer tubing, water levels are determined by using a capillary tube. Colored or clear water is placed in a small "U"-shaped loop in one end of the tube (the rest of the tube contains air). The other end of the capillary tube is lowered down the piezometer tubing until the water in the loop moves, indicating that the water level has been reached. The point is then measured from the bottom of the capillary tube or recorded if the capillary tube is calibrated. This is the best method for very small diameter tubing monitoring systems such as Barcad and other multilevel samples. Unless the capillary tube is calibrated, two people may be required to measure the length of capillary tubing used to reach the groundwat r. Since the piezometer tubing and capillary tubing usually are som what coiled wh n installed, it is difficult to accurately measure absolute water level elevations using this method. How v r, the m thod is us ful in accurately measuring differences or changes in water levels (i e., during pumping tests).

Pressure Transducer

Pressure transducers can be lowered into a well or borehole to measure the pressure of water and therefore the water elevation above the transducer. The transducer is wired into a recorder at the surface to record changes in water level with time. The recorder digitizes the information and can provide a printout or transfer the information to a computer for evaluation (using a well drawdown/recovery model). The pressure transducer should be initially calibrated with another water level measurement technique to ensure accuracy. This technique is very useful for hydraulic conductivity testing in highly permeable material where repeated, accurate water level measurements are required in a very short period of time. A sensitive transducer element is required to measure water levels to 0.01 foot accuracy.

Borehole Geophysics

Approximate water levels can be determined during geophysical logging of the borehole (although this is not the primary purpose for geophysical logging and such logging is not cost-effective if used only for this purpose). Several logging techniques will indicate water level. Commonly-us d logs which will indicate saturated/unsaturated conditions include the spontaneous potential (SP) log and th neutron log.

Bailer Line Method

Water levels can be measured during a bailing test of a well by marking and measuring the bailer line from the bottom of the bailer (where water is first encountered) to the point even with the top of the well casing. This is a useful technique during bailing tests (particularly if recovery is rapid) if the bailer is heard hitting the water. However, it is not recommended for measuring static water levels because it is not usually as accurate as some of the other methods described above.

5.2.3 Data Recording

Water level measurements, time, data, and weather conditions shall be recorded in the g ologist's field notebook or on the Groundwater Level Measurement Sheet. All water level measurements shall be measured from a known reference point. The reference point is generally a marked point on the upper edge of the inner well casing that has been surveyed for an elevation. The exact reference point shall be marked with permanent ink on the casing since the top of the casing may not be entirely level. It is important to note changes in weather conditions because changes in the barometric pressure may affect the water level within the well.

5.2.4 Specific Quality Control Procedures for Water Level Measuring Devices

All groundwater level measurement devices must be cleaned before and after each use to prev nt cross contamination of wells.

Some devices used to measure groundwater levels may need to be calibrated. These devices shall be calibrated to 0.01 foot accuracy periodically. A water level indicator calibration sheet shall be completed each time the measuring device is checked. A water level indicator calibration form is sh wn in Attachment A. The "actual reading" column on the sheet is the actual length of the interval from the end of the indicator t the appropriate marked depth interval. In many cas s, these measurem nts are different because th wat r level measuring device is connected to the end of the measuring tap r line, and may extend beyond "0" fe t on the measuring line.

5.3 POTENTIOMETRIC SURFACE MAPPING

5.3.1 Selection of Wells

All wells used to prepare a flow net in a plan or map view should represent the same hydrogeologic unit, be it aquifer or aquitard. All water level measurements used shall be collected on the same day.

Before mapping, review the recorded water levels and monitoring-well construction data, site geology and topographic setting to ascertain that the wells are completed in the same hydrogeologic unit and to determine if strong vertical hydraulic gradients may be present. Such conditions will be manifested by a pronounced correlation between well depth and water level, or by a difference in water level between two wells located near each other but set to different depths or having different screen lengths. Professional judgment of the hydrogeologist is important in this decision. If vertical gradients are significant, the data to be used must be limited vertically, and only wells finished in a chosen vertical zone of the hydrogeologic unit can be used.

At least three wells must be used to provide an estimation of the direction of groundwater flow, and many more wells will be needed to provide an accurate contour map. Generally, shallow systems require more wells than deep systems for accurate contour mapping.

5.3.2 Construction of Equipotential Lines

Plot the water elevations in the chosen wells on a site map. Other hydrogeologic features associated with the zone of interest -- such as seeps, wetlands, and surface-water bodies -- should also be pl tted along with their elevations.

The data should then be contoured, using mathematically valid and generally accepted techniques. Linear interpolation is most commonly used, as it is the simplest technique. However, quadratic interpolation or any technique of trend-surface analysis or data smoothing is acceptable. Computer-generated contour maps may be useful for large data sets. Contour lines shall be drawn as smooth, continuous lines which never cross one another.

Inspect the contour map, noting known features, such as pumping wells and site topography. The contour lines must be adjusted in accordance with these, utilizing the professional judgment of the hydrogeologist. Closed contours should be avoided unless a known sink exists. Groundwater mounding is common under landfills and lagoons; if the data imply this, the feature must show in the contour plot.

5.3.3 Determination of Groundwater-Flow Direction

Flow lines shall be drawn so that they are perpendicular to equipotential lines. Flow lines will begin at high head elevations and end at low head elevations. Closed highs will be the source of additional flow lines. Closed depressions will be the termination of some flow lines. Care must be used in areas with significant vertical gradients to avoid erroneous conclusions concerning gradients and flow directions.

5.4 HEALTH AND SAFETY CONSIDERATIONS

Groundwater c ntaminated by v latile organic compounds may release toxic vapors into the air space inside th well pipe. The release of this air wh n the well is initially opened is a Health/Saf ty hazard which must be consid r d. Initial monitoring of th well headspace and breathing zone concentrations using a PID (HNU) or FID (OVA) and combustible gas meters shall be performed to determine required levels of protection.

6.0 REFERENCES

Freeze, R. A. and J. A. Cherry, 1979. Groundwater. Prentice-Hall, Englewood Cliffs, New Jersey, 604 pp.

Cedergren, H. R., 1977. Seepage, Drainage and Flow Nets (2nd edition). John Wiley and Sons, New York.

Fetter, C. W., 1980. Applied Hydrogeology. Me ', Columbus, Ohio, 488 pp.

7.0 ATTACHMENTS

Attachment A - Groundwater Level Measurem ieet

Attachment B - Water Level Indicator Calibration Sheet.

ATTACHMENT A

GROUNDWATER LEVEL MEASUREMENT SHEET

LOCATION

Project Name: ______________________
Project No.: ______________________
Personnel: ______________________
Date: ______________________

Municipality: ______________________
County: ______________________
State: ______________________
Street or ______________________
Map Location ______________________
(If Off-Site)

WEATHER CONDITIONS

Temperature Range: ______________
Pr cipitation: ______________
Barometric Pressure: ______________

Equipment No.: ______________
Equipment Name: ______________
Latest Calibration Date: ______________

Tidally-Influenced: [ ] Yes [ ] No

Well or Piezometer Number	Date/Time	Elevation of Reference Point (Feet)*	Water Level Indicator Reading (Feet)*	Adjusted Depth (Feet)*	Groundwater Elevation (Feet)*

* All elevations to nearest 0.01 foot.

ATTACHMENT B

WATER LEVEL INDICATOR CALIBRATION SHEET

Project Name ______________________ Date ______________________

Project No. ______________________

Equipment No. ______________________

Equipment Name ______________________

Water Level Indicator Marking (Feet)	Actual Reading* (Feet)
0.0	
5.0	
10.0	
15.0	
20.0	
25.0	
30.0	
35.0	
40.0	
45.0	
50.0	
55.0	
60.0	
65.0	
70.0	
75.0	
80.0	
85.0	
90.0	
95.0	
100.0	

* Record readings to the nearest 0.01 foot. The actual reading may be different than marking because the water level m asuring devic (electrode, popper, etc.) may extend beyond the "0" fe t mark n the measuring line.

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		Effective Date: 05/04/90	Revision: 2
		Applicability: EMG	
		Prepared: Health and Safety	
Subject: HNU PI-101 ORGANIC VAPOR METER		Approved: D. Senovich	

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- 5.5 INSTRUMENT ADVANTAGES
- 5.6 CAUTIONS

6.0 REFERENCES

7.0 ATTACHMENTS

1.0 PURPOSE

To establish procedures for the use, maintenance, and calibration of the HNU PI-101 Organic Vapor Meter.

2.0 SCOPE

Applies to each usage of the HNU PI-101 photoionization detector by NUS/EMG personnel.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

Office Health and Safety Supervisor (OHSS) - The OHSS shall insure that the user has b en appropriately trained and certified in the usage of the HNU instrument. He/she shall also insure that the instrument is properly maintained and calibrated prior to its release for field service.

Instrument User - The user should be personally secure that he/she has been adequately trained and understands the operation and limitations of the instrument. He/she is further responsible to insure that the appropriate probe(s) have been selected for compounds to be found on site and that th instrument has been calibrated and is working properly.

5.0 PROCEDURES

5.1 PRINCIPLE OF OPERATION

The HNU System portable photoionizer detects the concentration of many organic gases as well as a few inorganic gases. The basis for detection is the ionization of gaseous species. The incoming gas molecules are subjected to ultraviolet (UV) radiation, which is energetic enough to ionize many gaseous compounds. The molecule is transformed into charged-ion pairs, creating a current betw en two electrodes. Each molecule has a characteristic ionization potential, which is the energy required to remove an electron from the molecule, yielding a positively-charged ion and the free electron. Th instrument measures this energy level.

5.2 INSTRUMENT CONFIGURATION

Three probes, each containing a different UV light source, are available for use with the HNU. Probe en rgies are 9.5, 10.2, and 11.7eV. All three detect many aromatic and large-molecule hydrocarbons. The 10.2 and 11.7eV probes, in addition, detect some smaller organic molecules and som halogenated hydrocarbons. The 10.2eV probe is the most useful for environmental response work, since it is more durable than the 11.7eV probe and detects more compounds than the 9.5eV probe.

5.3 CALIBRATION

The primary HNU calibration gas is benzene (or isobutylene, a benzene equivalent). The span potentiometer knob is adjusted for benzene calibration. A kn b setting of zero increases the sensitivity to benzen appr ximately ten-f ld. The instrument's response can be adjusted t give more accurate readings for specific gases and eliminat the necessity for calibration charts. Daily calibration is to be performed in accordance with Attachment G.

5.4 SPECIALIZED USES

While the HNU is used primarily as a qualitative instrument, it can also be used to detect certain contaminants or at least to narrow the range of possibilities. Noting instrument response to a contaminant source with different probes can eliminate some contaminants from consideration. For instance, a compound's ionizing potential may be such that the 9.5eV probe produces no resp nse, but the 10.2 and 11.7eV probes do elicit a response. Also, HNU does not detect methane or hydrogen cyanide.

5.5 INSTRUMENT ADVANTAGES

The HNU is easy to use in comparison to many other types of monitoring instrumentation. Its range detection limit is also in the low parts per million range. Response time is rapid; the meter ne dle reaches 90 percent of the indicated concentration in 3 seconds for benzene. HNU can be zeroed in a contaminated atmosphere.

5.6 CAUTIONS

Th instrument can monitor only certain vapors and gases in air. Nonvolatile liquids, toxic solids, particulates, and many other toxic gases and vapors cannot be detected. Because the types of compounds that the HNU can detect is only a fraction of the chemicals possibly present at a field site, a zero reading does not necessarily signify the absence of air contaminants.

The instrument is nonspecific, and its response to different compounds is relative to the calibration setting. Instrument readings may be higher or lower then the true concentration. These discrepancies can be especially serious problems when monitoring for total contaminant concentrations, if several different compounds are being detected at once. In addition, the response of this instrument is not linear over the entire detection range. Care must, therefore, be taken when interpreting the data. All identifications should be reported as tentative until they can be confirmed by more precise analysis. Concentrations should be reported in terms of the calibration gas and span potentiometer of the gas-select-knob setting.

The instrument cannot be used as an indicator for combustible gases or oxygen deficiency.

6.0 REFERENCES

HNU Systems, Inc. Instruction Manual for Model PI 101 Photoionization Analyzer, 1975.

E. & E. FIT Operation and Field Manual: HNU Systems PI 101 Photoionization Detector and Century Systems (Foxboro) Model OVA-128 Organic Vapor Analyzer.

Pers nal Communication with Fran Connel, HNU Systems, Inc., January 4, 1984.

7.0 ATTACHMENTS

Attachment A - Start-up and Shutdown Procedures
Attachment B - Maintenance and Calibration Schedule
Attachment C - Calibration Procedure
Attachment D - Cleaning the UV Light Source Window
Attachment E - Cleaning the Ionization Chamber
Attachment F - Troubleshooting
Attachment G - Daily Calibration

ATTACHMENT A

START-UP AND SHUTDOWN PROCEDURES

Start-up

1. Attach the probe to the readout unit. Match the alignment key, then twist the connector clockwise until a distinct locking is felt.

2. Turn the FUNCTION switch to the battery check position. Check to ensure that the indicator reads within or beyond the green battery arc on the scale plate. If the indicator is below the green arc, or if the red LED comes on, the battery must be charged prior to using.

3. To zero the instrument, turn the FUNCTION switch to the STANDBY position and rotate the ZERO POTENTIOMETER until the meter reads zero. Wait 15-20 seconds to ensure that the zero adjustment is stable. If not, then readjust.

4. Check to see that the SPAN POTENTIOMETER is set at the appropriate setting for the probe being used. Follow procedures in Attachment G in the performance of daily calibrations.

5. Set the FUNCTION switch to the desired ppm range.

6. Listen for the fan operation to verify fan function.

7. Check instrument with an organic point source (such as a magic marker) prior to usage to verify instrument function.

Shut Down

1. Turn FUNCTION switch to OFF.

2. Place the instrument on the charger.

ATTACHMENT B

MAINTENANCE AND CALIBRATION SCHEDULE

Function	Frequency
Routine Calibration	Prior to each use*
• Factory Check-out and Calibration	Yearly or when malfunctioning
• Wipe Down Read-Out Unit	After each use
• Clean UV Light Source Window	Every month or as use and site conditions dictate
• Clean the Ionization Chamber	Monthly
• Recharge Battery	After each use

* In accordance with the specifications identified in Attachment G.

ATTACHMENT C

CALIBRATION PROCEDURE

Calibration Procedure 1

1. Run through start-up procedures as per Attachment 1.
2. Fill a sampling bag with HNU calibration gas of known contents.
3. Allow sample bag contents to be drawn into the probe and check response in ppm.
4. If the reading deviates ± 15 percent from the concentration of the calibration gas, the instrument requires maintenance.
5. Each office must develop a mechanism for the documentation of calibration results. This documentation includes:
   a. date inspected
   b. person who calibrated the instrument
   c. the instrument number (Serial number or Other ID number)
   d. the result of the calibration (ppm, probe ev, span pot setting)
   e. identification of the calibration gas (source, type, concentration)

Calibration Procedure 2 (for HNU Calibration Canisters Equipped with a Regulator)

1. Run through start up procedures as per Attachment 1.
2. Connect a sampling hose to the regulator outlet and the other end to the sampling probe of the HNU.
3. Crack the regulator valve.
4. Take reading after 5-10 seconds.
5. If the reading deviates ± 15 percent from the concentration of the calibration gas, the instrument requires maintenance.
6. Calibration documentation should be as in No. 5 above.

ATTACHMENT D

CLEANING THE UV LIGHT SOURCE WINDOW

1. Turn the FUNCTION switch to the OFF position and disconnect the sensor/probe from the Read Out/Control unit.

2. Remove the exhaust screw located near the base of the probe. Grasp the end cap in one hand and the probe shell in the other. Separate the end cap and lamp housing from the shell.

3. Loosen the screws on the top of the end cap and separate the end cap and ion chamber from the lamp housing, taking care that the lamp does not fall out of this housing.

4. Tilt the lamp housing with one hand over the opening, so that the lamp slides out of the housing into your hand.

5. The lamp window may now be cleaned with any of the following compounds using lens paper:

   a. HNU Cleaning Compound-All lamps except the 11.7 eV
   b. Carbon tetrachloride-All lamps except the 11.7 eV
   c. Methanol-All lamps

6. Following cleaning, reassemble by first sliding the lamp back into the lamp housing. Place the ion chamber on top of the housing, making sure the contacts are properly aligned.

7. Place the end cap on top of the ion chamber and replace the two screws. Tighten the screws only enough to seal the O-ring. <u>Do Not Overtighten</u>.

8. Line up the pins on the base of the lamp housing with pins inside the probe shell and slide th housing assembly into the shell. It will only fit one way.

ATTACHMENT E

CLEANING THE IONIZATION CHAMBER

1. Turn the FUNCTION switch to the OFF position and disconnect the sensor/probe from the Read Out/Control unit.

2. Remove the exhaust screw located near the base of the probe. Grasp the end cap in one hand and the probe shell in the other. Separate the end cap and lamp housing from the shell.

3. Loosen the screws on the top of the end cap and separate the end cap and ion chamber from the lamp housing, taking care that the lamp does not fall out of this housing.

4. The ion chamber may now be cleaned according to the following sequence:

   a. acetone rinse with agitation (10 min.), then dry (preferably with oven at 100°C).

   b. methanol rinse with agitation (10 min.), then dry (preferably with oven at 100°C).

5. Place the ion chamber on top of the housing, making sure the contacts are properly aligned.

7. Place the end cap on top of the ion chamber and replace the two screws. Tighten the screws only enough to seal the O-ring. Do Not Overtighten.

8. Line up the pins on the base of the lamp housing with pins inside the probe shell and slide the housing assembly into the shell. It will only fit one way.

ATTACHMENT F

TROUBLESHOOTING

To be performed by qualified technician only.

1. No meter response in any switch position (including BATT CHK).

   A. Broken meter movement.

      (1) Tip instrument rapidly from side to side. Meter needle should move freely and return to zero.

   B. Electrical connection to meter is broken.

      (1) Check all wires leading to meter and clean the contacts of quick-disconnects.

   C. Battery is completely dead.

      (1) Disconnect battery and check voltage with a volt-ohm meter.

   D. If none of the above solves the problem, consult the factory.

2. Meter responds in BATT CHK position, but reads zero or near zero for all others.

   A. Power supply defective.

      (1) Check power supply voltages per Figure 11 of the HNU owner's manual. If any voltage is out of specification, consult the factory.

   B. Input transistor or amplifier has failed.

      (1) Rotate zero control; meter should deflect up/down, as control is turned.

      (2) Open probe. Both transistors should be fully seated in sockets.

   C. Input signal connection broken in probe or readout.

      (1) Check input connector on printed circuit board. The input connector should be firmly pressed down.

      (2) Check components on back side of printed circuit board. All connections should be solid and no wires should touch any other object.

      (3) Check all wires in readout for solid connections.

ATTACHMENT G

DAILY CALIBRATION OF HNU PI-101

HNU PI-101 organic vapor meters are to be field calibrated at the beginning of each work day, prior to actual on site usage.

In order to accomplish this, HNUs assigned to jobs shall be accompanied with a calibration gas cylinder, an appropriate fitting, and a flexible connecting hose. The procedure for performing field calibration is as follows:

1. Connect the probe to the instrument and turn it on.
2. Attach the eight-inch extension to the probe.
3. Set the Span Potentiometer to the setting specified on the calibration cylinder.
4. Connect the cylinder fitting to the cylinder.
5. Connect the cylinder and the instrument together with the flexible tubing.
6. Open the cylinder valve and wait 15 seconds.
7. Instrument reading should coincide with the designed reading stated on the calibration cylinder label.
8. If item number 7 does not coincide, adjust the Span Potentiometer until the desired reading is achieved. Any such adjustments must be within the following limits:

Probe	Initial Span Pot. Setting	Maximum Acceptable Span Pot. Adjustment
9.5 eV	5.0	1.0
10.2 eV	9.8	8.5
11.7 eV	5.0	2.0

If these limits are exceeded, the sensitivity and accuracy of the instrument is hindered. At these points, the instruments are to be returned to the NUS Equipment Manager for inspection, necessary cleaning and maintenance, and recalibration.

The manufacturer also recommends that the lamp inside of the probe be checked twice per week (16 hours of use) and cleaned at least weekly. This involves removing any noticeable obstructions or contamination from the lamp by wiping it off with a clean, soft cloth being careful not to scratch the circular window.

ATTACHMENT G
DAILY CALIBRATION OF HNU PI-101
PAGE TWO

In using this instrument to protect NUS employees and subcontractors, it is imperative that it is accurately responding to airborne substances present at the work site. By implementing these procedures, this end will be better achieved.

Additionally, all calibration activities must be documented in field log books, instrument calibration log sheets, or equivalent. This information must include the date inspected, the person calibrating the instrument, the instrument serial or identification number, the probe lamp eV (9.5 , 10.2, or 11.7), identification of calibration gas (gas source stated on the cylinder label), the initial and final Span Potentiometer settings, and the instrument resultant reading. This information must be submitted to the Site Safety officer at the completion of the job.

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- 5.5 CAUTIONS

6.0 REFERENCES

7.0 ATTACHMENTS

1.0 OBJECTIVE

To establish procedures for the use, maintenance, and calibration of the OVA 128 Vapor Analyzer.

2.0 SCOPE

Applies to each usage of the OVA instrument in implementation of the NUS/EMG Program.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

Office Health and Safety Supervisor (OHSS) - The OHSS shall insure that the user has been appropriately trained and certified in the usage of the OVA. He shall also insure that the instrument is properly maintained and calibrated prior to its release for field service.

Instrument User - The user should be personally secure that he or she has been adequately trained, understands the operation of the OVA, and limitations of the instrument. He or she should also be sure that the instrument has been calibrated and is working properly.

5.0 PROCEDURES

5.1 PRINCIPLE OF OPERATION

The OVA operates in two different modes. In the survey mode, it can determine the approximate concentration of all detectable species in air. With the gas chromatograph option, individual components can be detected and measured independently, with some detection limits as low as a few parts per billion.

5.2 GAS CHROMATOGRAPH FUNCTION

In the Gas Chromatograph (GC) mode, a small sample of ambient air is injected into a chromatographic column and carried through the column by a stream of hydrogen gas. C ntaminants with different chemical structures are retained on the column for different lengths of time (known as retention times) and, hence, are detected separately by the flame ionization detector. A strip chart recorder can be used to record the retention times, which are then compared to the retention times of a standard with known chemical constituents. The sample can be injected into the column either from the air-sampling hose or directly from a gas-tight syringe.

5.3 CALIBRATION

The OVA is internally calibrated to methane by the manufacturer. When measuring methane, it indicates the true concentration. In response to all other detectable compounds, however, the instrument reading may be higher or lower than the true concentration. Relative response ratios for substances other than methane are available. To interpret the readout correctly, it is necessary either to make calibration charts relating the instrument readings to the true concentrations or to adjust the instrument, so that it reads correctly. This second procedure is done by turning the 10-turn, gas-select knob, which adjusts the response of the instrument. The knob is normally set at 300 when calibrated to methane. Secondary calibration to another gas is done by sampling a known concentration of the gas and adjusting the gas-select knob, until the instrument reading equals the true concentration.

5.4 LIMITATIONS

The OVA has an inherent limitation in that it can detect only organic molecules. Also, it should not be used at temperatures lower than about 40°F, because gases condense in the pump and column. It has no temperature control and, since retention times vary with ambient temperatures for a given column, absolute determinations of contaminants are difficult. Despite these limitations, the GC mode can often provide tentative information on the identity of contaminants in air without relying on costly, time-consuming laboratory analysis.

5.5 CAUTIONS

The instrument can monitor only certain vapors and gases in air. Many nonvolatile liquids, toxic solids, particulates, and other toxic gases and vapors cannot be detected. Because the types of c mpounds that the OVA can potentially detect are only a fraction of the chemicals possibly pres nt at an incident, a zero reading does not necessarily signify the absence of air contaminants.

The instrument is nonspecific, and its response to different compounds is relative to the calibration setting. Instrument readings may be higher or lower than the true concentrations. These discrepancies can be especially serious problems when monitoring for total contaminant c ncentrations, if several different compounds are being detected at once. In addition, the response of this instrument is not linear over the entire detection range. Care must, therefore, be taken when interpreting the data. All identifications should be reported as tentative until they can be confirmed by m re precise analysis. Concentrations should be reported in terms of the calibration gas and span potentiometer or gas-select knob setting.

This instrument cannot be used as an indicator for combustible gases or oxygen deficiency.

6.0 REFERENCES

Century Systems (Foxboro). Service Procedures: Organic Vapor Analyzer; 128GC.

7.0 ATTACHMENTS

Attachment A	–	Start-up and Shutdown Procedures (2 Sheets)
Attachment B	–	Maintenance and Calibration Schedule
Attachment C	–	Calibration Procedure (2 Sheets)
Attachment D	–	Pump System Checkout
Attachment E	–	Burner Chamber Cleaning
Attachment F	–	Quad Ring Service
Attachment G	–	Troubleshooting (2 Sheets)
Attachment H	–	Shipping
Attachment I	–	D.O.T. Exemption Permit (2 Sheets)
Attachment J	–	D.O.T. Exemption Permit Extension
Attachment K	–	Hydrogen Recharging
Attachment L	–	Particle Filter Servicing
Attachment M	–	Flow Diagram - Gas Handling System

ATTACHMENT A

START-UP AND SHUTDOWN PROCEDURES

START-UP

1. Connect the probe/read out connectors to the side-pack assembly.
2. Check battery condition and hydrogen supply.
3. For measurement taken as methane equivalent, check that the GAS SELECT Dial is set at 300.
4. Turn the electronics on by moving the INSR switch to the ON position and allow five (5) minutes for warm-up.
5. Set CALIBRATE switch to X10, use CALIBRATE knob to set indicator at 0.
6. Open the H_2 tank valve and the H_2 supply valve all the way. Check that the hydrogen supply gauge reads between 8.0 and 12.0 psig.
7. Turn the PUMP switch ON and check the flow system, according to the procedures in Attachment D.
8. Check that the BACKFLUSH and INJECT valves are in the UP position.
9. To light the flame, depress the igniter switch until a meter deflection is observed. The igniter switch may be depressed for up to five (5) seconds. Do not depress for longer than five (5) seconds, since it may burn out the igniter coil. If the instrument does not light, allow it to run several minutes and repeat ignition attempt.
10. Confirm OVA operational state by sniffing an organic source, such as a magic marker.
11. Establish a background level in a clean area, by using the charcoal scrubber (depress the sample inject valve) and recording measurements referenced to background.
12. Set the alarm level, if desired.

SHUT DOWN

1. Close H_2 supply valve and H_2 tank valve (Do Not Overtighten Valves).
2. Turn INSTR switch to OFF.
3. Wait until H_2 supply gauge indicates system is purged of H_2, then switch off pump.
4. Put instrument on electrical charger at completion of day's activities.

ATTACHMENT B

MAINTENANCE AND CALIBRATION SCHEDULE

Check Particle Filters	Weekly or as-needed
Check Quad Rings	Monthly or as-needed
• Clean Burner Chamber	Monthly or as-needed
.S condary Calibration Check	Prior to project start-up
Primary Calibration Check	Monthly or if secondary check is off by more than ± 10%
• Check Pumping System	Prior to project start-up
Replace Charcoal	120 hours of use or when background readings are higher with the inject valve down than with the inject valve up, in a clean environment.
Factory Service	At least annually

- Instruments which are not in service for extended periods of time need not meet the above schedule. However, they must be given a complete check-out prior to their first use addressing the above maintenance items.

ATTACHMENT C

CALIBRATION PROCEDURE

PRIMARY CALIBRATION

1. Remove instrument components from the instrument shell.

2. Turn on Electronics and Zero instrument on X10 scale. Gas select dial to 300.

3. Turn on Pump and Hydrogen. Ignite Flame. Go to Survey Mode.

4. Introduce a Methane Standard near 100 ppm.

5. Adjust R-32 Trimpot on Circuit Board to make meter read to standard.

6. Turn off hydrogen flame and adjust meter needle to read 40 ppm (calibrate @ X10) using the calibration adjust knobs.

7. Switch to X100 Scale. The meter should indicate 0.4 on the 1-10 meter markings (0.4 x 100 = 40 ppm). If the reading is off, adjust with R33 Trimpot.

8. Return to X10 Scale and adjust meter needle to 40 ppm with calibration adjust knob, if necessary.

9. At the X10 Scale, adjust meter to read 0.4 on the 1-10 meter markings using the calibration adjust. Switch to X1 scale. The meter should read 4 ppm. If the reading is off, adjust using the R-31 Trimpot.

SECONDARY CALIBRATION

1. Fill an air sampling bag with 100 ppm (Certified) methane calibration gas.

2. Connect the outlet of the air sampling bag to the air sampling line of the OVA.

3. Record the reading obtained off the meter onto the calibration record.

DOCUMENTATION

Each office shall develop a system, whereby the following calibration information is recorded.

a. Instrument calibrated (I.D. or Serial No.)

b.)ate of calibration

c. Method of calibration

d. Results of the calibration

e. Identification of p rson wh calibrated the instrument

f. Identification of the calibration gas (source, type, concentration, Lot No.)

ATTACHMENT D

PUMP SYSTEM CHECKOUT

1. With pump on hold unit upright and observe flow gauge.
2. Ball level significantly below a reading of 2 is inadequate flow.
3. Check connections at the sample hose.
4. Clean or replace particle filters, if flow is impaired or it is time for scheduled service.
5. Reassemble and retest flow.
6. If flow still inadequate, replace pump diaphragm and valves.
7. If flow normal, plug air intake. Pump should slow and stop.
8. If no noticeable change in pump, tighten fittings and retest.
9. If still no change, replace pump diaphragm and valves.
10. Document this function in the maintenance records.

ATTACHMENT E

BURNER CHAMBER CLEANING

1. Remove plastic exhaust port cover.
2. Unscrew exhaust port.
3. Use wire brush to clean burner tip and electrode. Use wood stick to clean Teflon.
4. Brush inside of exhaust port.
5. Blow out chamber with a gentle air flow.
6. Reassemble and test unit.
7. Document this function in the maintenance records.

ATTACHMENT F

QUAD RING SERVICE

1. Remove OVA guts from protective shell.
2. Remove clip ring from bottom of valve.
3. Unscrew nut from top of valve.
4. Gently pull valve shaft upward and free of housing.
5. Observe rings for signs of damage - replace as necessary.
6. Lightly grease rings with silicone grease.
7. Reassemble valve - do not pinch rings during shaft insertion.
8. Document this function in the maintenance records.

ATTACHMENT G

TROUBLESHOOTING

Indication	Possible Causes
• High Background Reading (More than 10 ppm)	1. Contaminated Hydrogen 2. Contaminated Sample Line
Continual Flameout	1. Hydrogen Leak 2. Dirty Burner Chamber 3. Dirty Air Filters
• Low Air Flow	1. Dirty Air Filter 2. Pump Malfunction 3. Line Obstruction
Flame Will Not Light	1. Low Battery 2. Ignitor Broken 3. Hydrogen Leak 4. Dirty Burner Chamber 5. Air Flow Restricted
• No Power to Pump	1. Low Battery 2. Short Circuit
Hydrogen Leak (Instrument Not in Use)	1. Leak in Regulator 2. Leak in Valves

ATTACHMENT G
TROUBLESHOOTING
PAGE TWO

To be performed by qualified technician only.

1. No meter response in any switch position (including BATT CHK).

   A. Broken meter movement.
      (1) Tip instrument rapidly from side to side. Meter needle should move freely and return to zero.

   B. Electrical connection to meter is broken.
      (1) Check all wires leading to meter and clean the contacts of quick-disconnects.

   C. Battery is completely dead.
      (1) Disconnect battery and check voltage with a volt-ohm meter.

   D. If none of the above solves the problem, consult the factory.

2. Meter responds in BATT CHK position, but reads zero or near zero for all others.

   A. Power supply defective.
      (1) Check power supply voltages per Figure 11 of the HNU owner's manual. If any voltage is out of specification, consult the factory.

   B. Input transistor or amplifier has failed.
      (1) Check input connector on printed circuit board. The input connector should be firmly pressed down.
      (2) Check components on back side of printed circuit board. All connections should be solid and no wires should touch any other object.
      (3) Check all wires in readout for solid connections.

ATTACHMENT H

SHIPPING

Since the OVA-128 contains hydrogen, it is subject to shipping restrictions.

As Personal Luggage

The OVA-128 can be taken on a plane as luggage, since a permit has been issued from the Department of Transportation to the manufacturer (Foxboro). Please refer to the original permit (Attachment 9) and the extended permit (Attachment 10).

Air Express

The following labels must be affixed to both sides of the OVA case when shipping OVA by Air Express.

- Danger - Peligro
- Flammable Gas
- Inside Container Complies with D.O.T. Regulations
- Hydrogen UN #1049
- Name and Address of Recipient

A hazardous air bill must be filled out. The following information is requested.

Proper Shipping Name	Hydrogen
Classification	Flammable Gas
I.D. No.	UN 1049
Net Quantity	75 Cubic Centimeters

In addition, the shipping's certification must be signed and marked CARGO AIRCRAFT ONLY.

ATTACHMENT I
D.O.T. EXEMPTION PERMIT

DEPARTMENT OF TRANSPORTATION
RESEARCH AND SPECIAL PROGRAMS ADMINISTRATION
WASHINGTON DC 20590

DRAFT

DOT-E 7607
(FIRST REVISION - CORRECTED COPY)

1. Century Systems Corporation, Arkansas City, Kansas, is hereby granted an exemption from those provisions of this Department's Hazardous Materials Regulations specified in paragraph 5 below to offer packages prescribed herein of a flammable gas for transportation in commerce subject to the limitations and special requirements specified herein. This exemption authorizes the shipment of hydrogen in certain non-DOT specification cylinders as described in paragraph 7 below, and provides no relief from any regulation other than as specifically stated. Each of the following is hereby granted the status of a party to this exemption:

U.S. Department of Health, Education and Welfare, Rockville, Maryland - PTE-1.

2. BASIS. This exemption is based on Century Systems Corporation's application dated March 10, 1978, submitted in accordance with 49 CFR 107.105 and the public proceeding thereon. The granting of party status is based on the following application submitted in accordance with 49 CFR 107.111 and the public proceeding thereon:

The U.S. Department of Health, Education and Welfare's application dated March 13, 1978.

3. HAZARDOUS MATERIALS (Descriptor and class). Hydrogen, flammable gas.

4. PROPER SHIPPING NAME (49 CFR 172.101). Hydrogen.

5. REGULATION AFFECTED. 49 CFR 172.101, 175.3.

6. MODE OF TRANSPORTATION AUTHORIZED. Passenger-carrying aircraft.

7. SAFETY CONTROL MEASURES. Packaging prescribed is a non-DOT specification seamless stainless steel cylinder of not more than 7.22 cubic inch water capacity; each cylinder to be pressure tested to at least 4000 psig, and charged to not more than 2100 psig at 70°F. The cylinder is a component part of a portable gas chromatograph.

8. SPECIAL PROVISIONS.

a. Each device must be shipped in a strong outside packaging as prescribed in 49 CFR 173.301(h).

b. A copy of this exemption must be carried aboard each aircraft used to transport packages covered by this exemption.

c. The pilot in command must be advised when the gas chromatograph is placed on board the aircraft.

d. The gas chromatograph must be appropriately secured.

Continuation of 1st Rev. DOT-E 7607 corrected copy

DRAFT

9. REPORTING REQUIREMENTS. Any incident involving loss of contents of the package must be reported to the Office of Hazardous Materials Regulation as soon as practicable.

10. EXPIRATION DATE. May 1, 1980.

ued at Washington, D.C.:

9-7-78
(DATE)

Alan I. Roberts
Associate Director for
Hazardous Materials Regulation
Materials Transportation Bureau

Address all inquiries to: Associate Director for Hazardous Materials Regulation, Materials Transportation Bureau, Research and Special Programs Administration, Department of Transportation, Washington, D.C., 20590. Attention: Exemptions Branch.

Dist: 3 of E, FAA

DEPARTMENT OF TRANSPORTATION
RESEARCH AND SPECIAL PROGRAMS ADMINISTRATION
WASHINGTON, D.C. 20590

DOT-E 7607
(PTE)

In accordance with 49 CFR 107.111 of the Department of Transportation (DOT) Hazardous Materials Regulations the party(s) listed below are granted the status of party to DOT-E 7607.

The expiration date of the exemption is March 11, 1982 for the party(s) listed below. This authorization forms part of the exemption and must be attached to it.

13 JUN 1980
(DATE)

Alan I. Roberts
Associate Director for
Hazardous Materials Regulation
Materials Transportation Bureau

Dist: FAA

EXEMPTION HOLDER	APPLICATION DATE
Clayton Environmental Consultants, Inc. Southfield, Michigan	December 5, 1979
Foxboro Company Burlington, MA	March 24, 1980

ATTACHMENT J

D.O.T. EXEMPTION PERMIT EXTENSION

U.S. Department of Transportation
Research and Special Programs Administration

400 Seventh Street, S W
Washington, D C 20590

DOT-E 7607
(EXTENSION)

In accordance with 49 CFR 107.105 of the Department of Transportation (DOT) Hazardous Materials Regulations DOT-E 7607 is hereby extended by changing the expiration date in paragraph 10 from December 1, 1983 to September 1, 1985.

This extension applies only to party(s) listed below based on the application received in accordance with 49 CFR 107.105. All other terms of the exemption remain unchanged. This extension forms part of the exemption and must be attached to it.

J.R. Grothe for
Alan I. Roberts
Associate Director for
Hazardous Materials Regulation
Materials Transportation Bureau

OCT 27 1983
(DATE)

Dist: FAA

EXEMPTION HOLDER	APPLICATION DATE
Foxboro Company South Norwalk, Ct.	September 16, 1983

ATTACHMENT K

HYDROGEN RECHARGING

1. High grade hydrogen (99.999%) is required.
2. Connect the fill hose to the REFILL FITTING on the side Pack Assembly, with the FILL/BLEED valve in the OFF position.
3. Open H_2 supply bottle valve.
4. Place FILL/BLEED valve on fill hose in BLEED position momentarily to purge any air out of the system.
5. Crack the instrument TANK VALVE.
6. Open REFILL valve on instrument.
7. Place FILL/BLEED valve in FILL position until the instrument PRESSURE GAUGE equalizes with the H_2 SUPPLY BOTTLE PRESSURE GAUGE.
8. Shut REFILL valve, FILL/BLEED valve, and H_2 SUPPLY BOTTLE valve, in quick succession.
9. Turn FILL/BLEED valve to BLEED until hose pressure equalizes to atmospheric pressure.
10. Turn FILL/BLEED valve to FILL Position, then to BLEED position, then to OFF.
11. Close TANK on instrument.
12. Disconnect the FILL HOSE and replace protective nut on the REFILL FITTING.

ATTACHMENT L

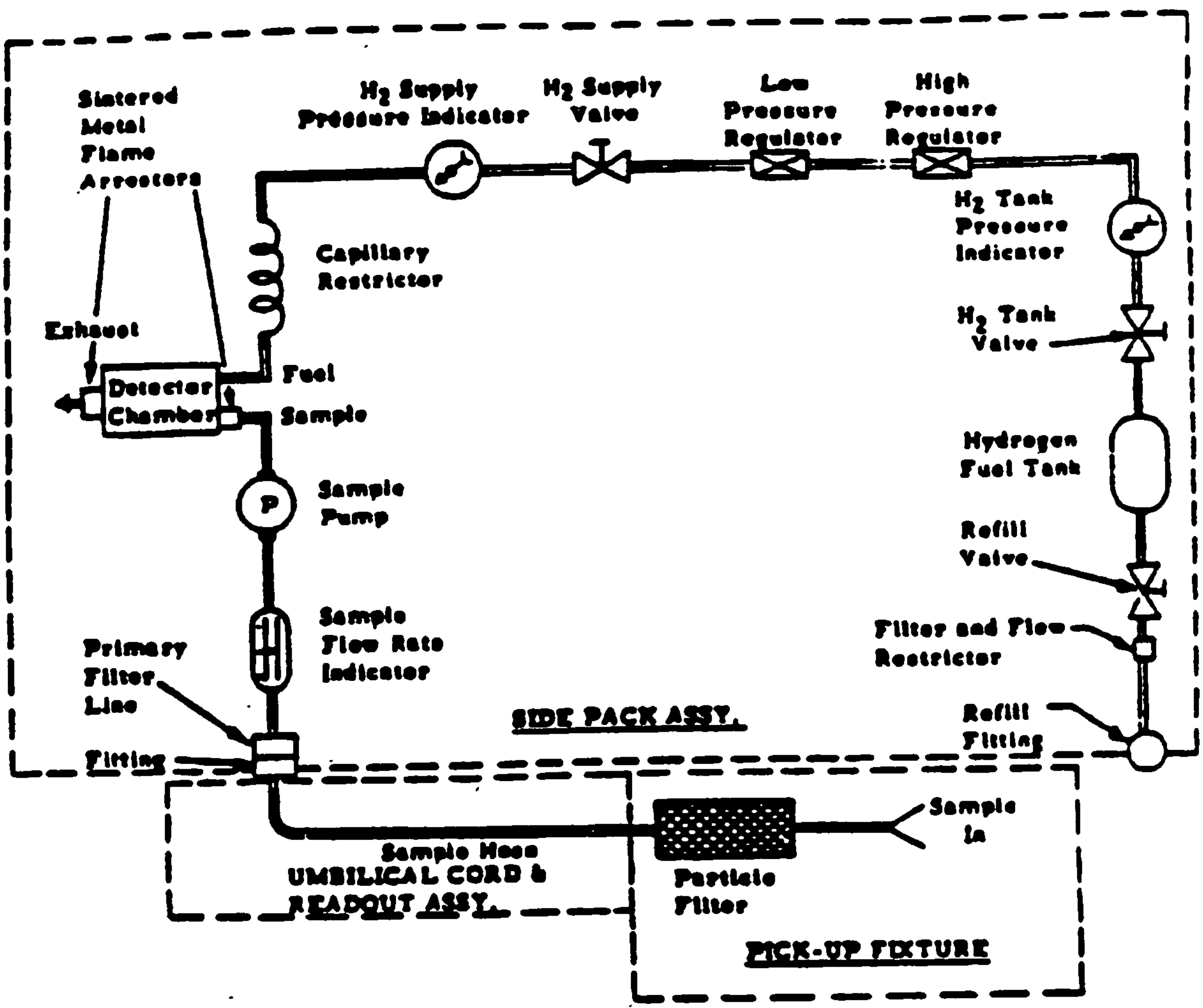
PARTICLE FILTER SERVICING

There are two points in the air sampling line of the OVA where filters have been placed to keep particulates from entering the instrument. The location of these filters are indicated on the figure in Attachment M. The first filter is located in the probe assembly and the second filter (primary filter) is located on the side pack assembly. Cleaning procedures are as follows:

1. Detach the probe assembly from the readout assembly.
2. Disassemble the probe (the components unscrew).
3. The particle filter located within the probe can be cleaned by blowing air through the filter.
4. Reassemble the probe.
5. The primary filter, located behind the sample inlet connector on the side pack assembly, is accessed by removing the sample inlet connector with a thin-walled 7/16 inch socket wrench. Remove the filter and clean as above.
6. Reassemble the sample inlet fitting and filter to the side pack assembly.
7. Check sample flow rate.

ATTACHMENT M

FLOW DIAGRAM - GAS HANDLING SYSTEM



NUS CORPORATION

ENVIRONMENTAL MANAGEMENT GROUP

STANDARD OPERATING PROCEDURES

Number ME-11	Page 1 of 4
Effective Date 05/04/90	Revision 2
Applicability EMG	
Prepared Health and Safety	
Approved D. Senovich	

Subject GENERAL CALIBRATION REQUIREMENTS

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1.0 PURPOSE

2.0 SCOPE

3.0 GLOSSARY

4.0 RESPONSIBILITIES

5.0 PROCEDURES

6.0 REFERENCES

7.0 RECORDS

1.0 PURPOSE

To establish a procedure delineating minimum requirements for equipment and instrument calibration.

2.0 SCOPE

This procedure is applicable to all instruments used on NUS projects or by NUS staff to acquire data used for health, safety, or training purposes; used to fulfill project objectives; or which require calibration as per manufacturer's specifications.

3.0 GLOSSARY

Instrument - Any data-gathering device.

Calibration - An operational check of a monitoring or detecting device, which yield, an expected resp nse when operated with a known standard.

Equipment Manager - Person assigned responsibility for equipment storage and use. All calibration functions shall be documented and maintained by the Equipment Manager responsible for the instruments involved.

4.0 RESPONSIBILITIES

It is the responsibility of each NUS office manager to ensure the implementation and maintenance of this procedure. Other responsibilities involved with this procedure shall be addressed by personnel function.

5.0 PROCEDURES

Calibration Responsibilities - Instruments requiring calibration shall be calibrated according to their respective manufacturer's specifications, be given an operational check, and be calibrated prior t assignment to a project. Only qualified individuals, knowledgeable (or certified, if applicable) in the prop r procedures, are permitted to perform instrument calibration. It is unacceptable (and shall not be permitted) to use any instrument which requires calibration before it is successfully calibrated. It is the responsibility of the equipment operator/user to ensure that all instruments in his/her control hav been calibrated and are given an operational check prior to field use.

Procedures and Schedules - Calibration frequencies and procedures shall follow: (1) NUS Operating Procedures or (2) manufacturer's specifications.

Recordkeeping - All calibration activities must and shall be documented to ensure compliance with both applicable regulatory standards and with the requirements of this program. Proper and timely documentation is the responsibility of the person(s) performing the calibration. These records shall be updated and maintained for at least the life of the instrument. All equipment calibration efforts shall be documented, using calibration cards (see Attachment A). Items that must be included n these documents shall include either the manufacturer's recommendations or those items specified in the Standard Operating Procedures. Any equipment maintenance efforts also shall be documented using the Maintenance Service r cord (see Attachment A). It shall be the responsibility of the Equipment Manager in each office to maintain these rec rds.

Upon use and task completion, the user/operator is required to document any problems or malfunctions noted throughout the use. This information shall be accompanied by the user/operator's name, identification of the instrument involved, and identification of the job/project involved. This information shall be used to inspect, repair, and/or maintain instruments. Any such activities shall be conducted in accordance with Equipment Tagging Procedures.

Equipment calibration is an auditable function. Therefore, accurate recordkeeping shall be maintained to ensure compliance with this program as well as to monitor that all persons are fulfilling their respective responsibilities.

6.0 REFERENCES

None.

7.0 ATTACHMENTS

Attachment A – Calibration and Maintenance Service Cards

ATTACHMENT A

CALIBRATION (EXAMPLE 1) AND MAINTENANCE SERVICE (EXAMPLE 2) CARDS

EXAMPLE 1

ITEM		I.D.	INV #	REQUIREMENTS
DATE	PERSON	REMARKS		

EXAMPLE 2

ITEM	MOD #	COST	INV #
	SER #	RENTAL	ID#
	MFR #	MONTH	

DATE	MAINTENANCE SERVICE/REMARKS

D334901

NUS CORPORATION ENVIRONMENTAL MANAGEMENT GROUP	STANDARD OPERATING PROCEDURES	Number: SA-1 1	Page: 1 of 14
		Effective Date: 05/04/90	Revision: 2
		Applicability: EMG	
		Prepared: Earth Sciences	
Subject: GROUNDWATER SAMPLE ACQUISITION		Approved: D Senovich	

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- 5.7 CHAIN-OF-CUSTODY

6.0 REFERENCES

7.0 ATTACHMENTS

1.0 PURPOSE

The purpose of this procedure is to provide general reference information on the sampling of groundwater wells. The methods and equipment described are for the collection of water samples from the saturated zone of the subsurface.

2.0 SCOPE

This procedure provides information on proper sampling equipment and techniques for groundwater sampling. Review of the information contained herein will facilitate planning of the field sampling effort by describing standard sampling techniques. The techniques described shall be followed whenever applicable, noting that site-specific conditions or project-specific plans may require adjustments in methodology.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

Site Hydrogeologist or Geochemist - responsible for selecting and detailing the specific groundwater sampling techniques and equipment to be used, documenting these in the Project Operations Plan (POP), and properly briefing the site sampling personnel.

Site Geologist - The Site Geologist is primarily responsible for the proper acquisition of the groundwater samples. When appropriate, such responsibilities may be performed by other qualified personnel (engineers, field technicians).

Site Manager - The Site Manager is responsible for reviewing the sampling procedures used by the field crew and for performing in-field spot checks for proper sampling procedures.

5.0 PROCEDURES

5.1 GENERAL

To be useful and accurate, a groundwater sample must be representative of the particular zone of the water being sampled. The physical, chemical, and bacteriological integrity of the sample must be maintained from the time of sampling to the time of testing in order to keep any changes in water quality parameters to a minimum.

Methods for withdrawing samples from completed wells include the use of pumps, compressed air, bailers, and various types of samplers. The primary considerations in obtaining a representative sample of the groundwater are to avoid collection of stagnant (standing) water in the well and to avoid physical or chemical alteration of the water due to sampling techniques. In a non-pumping well, there will be little or no vertical mixing of water in the well pipe or casing, and stratification will occur. The well water in the screened section will mix with the groundwater due to normal flow patterns, but the well water above the screen d s ction will remain isolated and become stagnant. To safeguard against collecting n n-representative stagnant water in a sample, the following approach shall be follow d prior to sample acquisition:

1 All monitoring wells shall be purged prior to obtaining a sample. Evacuation of three to five volumes is recommended for a representative sample. In a high-yielding groundwater formation and where there is no stagnant water in the well above the screened section, evacuation prior to sample withdrawal is not as critical.

2. For wells that can be purged to dryness with the sampling equipment being used, the well shall be evacuated and allowed to recover prior to sample acquisition. If the recovery rate is fairly rapid, evacuation of more than one volume of water is preferred.

3. For high-yielding monitoring wells which cannot be evacuated to dryness, there is no absolute safeguard against contaminating the sample with stagnant water. One of the following techniques shall be used to minimize this possibility:

- A submersible pump, intake line of a surface pump or bailer shall be placed just below the water surface when removing the stagnant water and lowered as the water level decreases. Three to five volumes of water shall be removed to provide reasonabl assurance that all stagnant water has been evacuated. Once this is accomplished a bailer may be used to collect the sample for chemical analysis.

- The inlet line of the sampling pump (or the submersible pump itself) shall be placed near the bottom of the screened section, and approximately one casing volume of water shall be pumped from the well at a rate equal to the well's recovery rate.

Stratification of contaminants may exist in the aquifer formation, both in terms of a concentration gradients due to mixing and dispersion processes in a homogeneous layer, and in layers of variable permeability into which a greater or lesser amount of the contaminant plume has flowed. Excessive pumping can dilute or increase the contaminant concentrations in the recovered sample compared to what is representative of the integrated water column at that point, and thus result in the collection of a non-representative sample.

5.2 SAMPLING, MONITORING, AND EVACUATION EQUIPMENT

Sample containers shall conform with EPA regulations for the appropriate contaminants.

The following equipment shall be on hand when sampling ground water wells:

- Sample packaging and shipping equipment - Coolers for sample shipping and cooling, chemical preservatives, appropriate packing containers and filler, ice, labels and chain-of-custody documents.

- Field tools and instrumentation - Thermometer; pH paper/meter; camera and film; tags; appropriate keys (for locked wells); engineers rule; water-level indicator; wher applicable, specific-conductivity meter.

- Pumps

  - Shallow-well pumps--Centrifugal, pitcher, suction, or peristaltic pumps with droplines, air-lift apparatus (compressor and tubing) where applicable.

  - Deep-well pumps--submersible pump and electrical power generating unit, or air-lift apparatus where applicable.

- Other sampling equipment - Bailers and monofilament line with tripod-pulley assembly (if necessary). Bailers shall be used to obtain samples for volatile organics from shallow and deep groundwater wells.

- Pails - Plastic, graduated.

- Decontamination solutions - Distilled water, Alconox, methanol, acetone.

Ideally, sample withdrawal equipment shall be completely inert, economical, easily cleaned, sterilized, and reused, able to operate at remote sites in the absence of power sources, and capable of delivering variable rates for well flushing and sample collection.

5.3 CALCULATIONS OF WELL VOLUME

To insure that the proper volume of water has been removed from the well prior to sampling it is first necessary to know the volume of standing water in the well pipe. This volume can be easily calculated by the following method. Calculations shall be entered in the field logbook and on the field data form (Attachment A):

- Obtain all available information on well construction (location, casing, screens, etc.).

- Determine well or casing diameter.

- Measure and record static water level (depth below ground level or top of casing reference point).

- Determine depth of well (if not known from past records) by sounding using a clean, decontaminated weighted tape measure.

- Calculate number of linear feet of static water (total depth or length of well pipe minus the depth to static water level).

- Calculate one static well volume in gallons ($V = 0.163Tr^2$).

  where:

V	=	Static volume of well in gallons.
T	=	Thickness of water table in the well measured in feet, i.e., linear feet of static water.
r	=	Inside radius of well casing in inches.
0.163	=	A constant conversion factor which compensates for the conversion of the casing radius from inches to feet, the conversion of cubic feet to gallons, and pi.

- Determine the minimum amount to be evacuated before sampling.

5.4 EVACUATION OF STATIC WATER (PURGING)

5.4.1 General

The amount of flushing a well shall receive prior to sample collection will depend on the intent of the monitoring program and the hydrogeologic conditions. Programs to determine overall quality of water resources may require long pumping periods to obtain a sample that is representative of a large volume of that aquifer. The pumped volume may be specified prior to sampling so that the sample can be a composite of a known volume of the aquifer. Alternately the well can be pumped until the parameters such as temperature, electrical conductance, and pH have stabilized. Onsite measurements of these parameters shall be recorded on the field data form.

For defining a contaminant plume, a representative sample of only a small volume of the aquifer is required. These circumstances require that the well be pumped enough to remove the stagnant water but not enough to induce significant groundwater flow from other areas. Generally three to five well volumes are considered effective for purging a well.

The site hydrogeologist, geochemist and risk assessment personnel shall define the objectives of the groundwater sampling program in the Work Plan, and provide appropriate criteria and guidance to the sampling personnel on the proper methods and volumes of well purging.

5.4.2 Evacuation Devices

The following discussion is limited to those devices commonly used at hazardous waste sites. Attachment B provides guidance on the proper evacuation device to use for given sampling situations. Note that all of these techniques involve equipment which is portable and readily available.

5.4.2.1 Bailers

Bailers are the simplest evacuation devices used and have many advantages. They generally consist of a length of pipe with a sealed bottom (bucket-type bailer) or, as is more useful and favored, with a ball check-valve at the bottom. An inert line is used to lower the bailer and retrieve the sample.

Advantages of bailers include:

- Few limitations on size and materials used for bailers.
- No external power source needed.
- Bailers are inexpensive, and can be dedicated and hung in a well to reduce the chances of cross-contamination.
- There is minimal outgassing of volatile organics while the sample is in the bailer.
- Bailers are relatively easy to decontaminate.

Limitations on the use of bailers include the following:

- It is time consuming to remove stagnant water using a bailer.
- Transfer of sample may cause aeration.
- Use of bailers is physically demanding, especially in warm temperatures at protection levels above Lev l D.

5.4.2.2 Suction Pumps

There are many different types of inexpensive suction pumps including centrifugal, diaphragm, peristaltic, and pitcher pumps. Centrifugal and diaphragm pumps can be used for well evacuation at a fast pumping rate and for sampling at a low pumping rate. The peristaltic pump is a low volume pump (therefore not suitable for well purging) that uses rollers to squeeze a flexible tubing, thereby creating suction. This tubing can be dedicated to a well to prevent cross contamination. The pitcher pump is a common farm hand-pump.

These pumps are all portable, inexpensive and readily available. However, because they are based on suction, their use is restricted to areas with water levels within 20 to 25 feet of the ground surface. A significant limitation is that the vacuum created by these pumps can cause significant loss of dissolved gases and volatile organics. In addition, the complex internal components of these pumps may be difficult to decontaminate.

5.4.2.3 Gas-Lift Samplers

This group of samplers uses gas pressure either in the annulus of the well or in a venturi to force the water up a sampling tube. These pumps are also relatively inexpensive. Gas lift samplers are more suitable for well development than for sampling because the samples may be aerated, leading to pH changes and subsequent trace metal precipitation or loss of volatile organics.

5.4.2.4 Submersible Pumps

Submersible pumps take in water and push the sample up a sample tube to the surface. Th power sources for these samplers may be compressed gas or electricity. The operation principles vary and the displacement of the sample can be by an inflatable bladder, sliding piston, gas bubble, or impeller. Pumps are available for 2-inch diameter wells and larger. These pumps can lift water from considerable depths (several hundred feet).

Limitations of this class of pumps include:

- They may have low delivery rates.
- Many models of these pumps are expensive.
- Compressed gas or electric power is needed.
- Sediment in water may cause clogging of the valves or eroding the impellers with some of these:pumps.
- Decontamination of internal components is difficult and time-consuming.

5.5 SAMPLING

5.5.1 Sampling Plan

The sampling approach consisting of the following, shall be developed as part of the POP prior to the field work:

- Background and objectives of sampling.

- Brief description of area and waste characterization.

- Identification f sampling locations, with map or sketch, and applicable well construction data (well size, depth, screened interval, reference elevation).

- Intended number, sequence volumes, and types of samples. If the relative degrees of contamination between wells is unknown or insignificant, a sampling sequence which facilitates sampling logistics may be followed. Where some wells are known or strongly suspected of being highly contaminated, these shall be sampled last to reduce the risk of cross-contamination between wells as a result of the sampling procedures.
- Sample preservation requirements.
- Working schedule.
- List of team members.
- List of observers and contacts.
- Other information, such as the necessity for a warrant or permission of entry, requirement for split samples, access problems, location of keys, etc.

5.5.2 Sampling Methods

The collection of a groundwater sample is made up of the following steps:

1 HSO or designee will first open the well cap and use volatile organic detection equipment (HNU or OVA) on the escaping gases at the well head to determine the need for respiratory protection.

2. When proper respiratory protection has been donned, sound the well for total depth and water level (using clean equipment) and record these data in a well sampling data sheet (Attachment A); then calculate the fluid volume in the well pipe.

3. Calculate well volume to be removed as stated in Section 5.3.

4. Select appropriate purging equipment (see Attachment B). If an electric submersible pump with packer is chosen, go to Step 10.

5. Lower purging equipment or intake into the well to a short distance below the water level and begin water removal. Collect the purged water and dispose of it in an acceptable manner. Lower the purging device, as required, to maintain submergence.

6. Measure rate of discharge frequently. A bucket and stopwatch are most commonly used; other techniques include using pipe trajectory methods, weir boxes or flow meters.

7. Observe peristaltic pump intake for degassing "bubbles." If bubbles are abundant and the intake is fully submerged, this pump is not suitable for collecting samples for volatile organics. Never collect volatile organics samples using a vacuum pump.

8. Purge a minimum of three-to-five casing volumes before sampling. In low permeability strata (i.e., if th well is pumped to dryness), one volume will suffice.

9. If sampling using a pump, lower the pump intake to midscreen or the middle of the open section in uncased wells and collect the sampl . If sampling with a bailer, lower the bailer to sampling level before filling (this requires use of ther than a 'bucket-type' bailer)

Purged water shall be collected in a designated container and disposed of in an acceptable manner.

10. (For pump and packer assembly only). Lower assembly into well so that packer is positioned just above the screen or open section and inflate. Purge a volume equal to at least twice the screened interval or unscreened open section volume below the packer before sampling. Packers shall always be tested in a casing section above ground to determine proper inflation pressures for good sealing.

11 In the event that recovery time of the well is very slow (e.g., 24 hours), sample collection can be delayed until the following day. If the well has been bailed early in the morning, sufficient water may be standing in the well by the day's end to permit sample collection. If the well is incapable of producing a sufficient volume of sample at any time, take the largest quantity available and record in the logbook.

12. Add preservative if required. Label, tag, and number the sample bottle(s).

13. Replace the well cap. Make sure the well is readily identifiable as the sourc of the samples.

14. Pack the samples for shipping. Attach a custody seal to the front and back of the shipping package. Make sure that traffic reports and chain-of-custody forms are properly filled out and enclosed or attached.

15. Decontaminate all equipment

5.5.3 Sample Containers

For most samples and analytical parameters, either glass or plastic containers are satisfactory.

5.5.4 Preservation of Samples and Sample Volume Requirements

Sample preservation techniques and volume requirements depend on the type and concentration of the contaminant and on the type of analysis to be performed. Procedure SF-1.2 describes th sample preservation and volume requirements for most of the chemicals that will be encountered during hazardous waste site investigations. Procedure SA-4.3 describes the preservation requirement for microbial samples.

5.5.5 Handling and Transporting Samples

After collection, samples shall be handled as little as possible. It is preferable to use self-contained "chemical" ice (e.g., "blue ice") to reduce the risk of contamination. If water ice is used, it shall be bagged and steps taken to ensure that the melted ice does not cause sample containers t be submerged and thus possibly become cross-contaminated. All sample containers shall be enclos d in plastic bags or cans to prevent cross-contamination. Samples shall be secured in the ice chest to prevent movement of sample containers and possible breakage. Sample packing and transportation requirements are described in SA-6.2.

5.5.6 Sample H lding Times

Holding times (i.e. allowed time b tween sample collection and analysis) f r routine samples are given in Procedure SF-1.2.

5.6 RECORDS

Records will be maintained for each sample that is taken. The sample log sheet will be used to record the following information:

- Sample identification (site name, location, project number; sample name/number and location; sample type and matrix; time and date; sampler's identity).
- Sample source and source description.
- Purge data - prior to removal of each casing volume and before sampling, pH, electrical conductance, temperature, color, and turbidity shall be measured and recorded.
- Field observations and measurements (appearance; volatile screening; field chemistry; sampling method).
- Sample disposition (preservatives added; lab sent to, date and time; lab sample number, EPA Traffic Report or Special Analytical Services number, chain-of-custody number.
- Additional remarks - (e.g., sampled in conjunction with state, county, local regulatory authorities; samples for specific conductance value only; sampled for key indicator analysis; etc.).

5.7 CHAIN-OF-CUSTODY

Proper chain-of-custody procedures play a crucial role in data gathering. Procedure SA-6.1 describes the requirements for a correct chain-of-custody.

6.0 REFERENCES

U.S. EPA, 1980. Procedures Manual for Ground Water Monitoring at Solid Waste Disposal Facilities. Office of Solid Waste, United States Environmental Protection Agency, Washington, D.C.

Johnson Division, UOP, Inc. 1975. Ground Water and Wells, A Reference Book for the Water Well Industry. Johnson Division, UOP, Inc., Saint Paul, Minnesota.

Barcelona, M. J., J. P. Gibb and R. A. Miller, 1983. A guide to the Selection of Materials for Monitoring Well Construction and Groundwater Sampling. ISWS Contract Report 327, Illinois State Water Survey, Champaign, Illinois.

Scalf, M. R., J. F. McNabb, W. J. Dunlap, R. L. Crosby and J. Fryberger, 1981. Manual of Ground Water Sampling Procedures. R. S. Kerr Environmental Research Laboratory, Office of Research and Development, U.S. EPA, Ada, Oklahoma.

Nielsen, D. M. and G. L. Yeates, 1985. A Comparison of Sampling Mechanisms Available for Small-Diameter Ground Water Monitoring Wells. Ground Water Monitoring Review 5:83-98.

7.0 ATTACHMENTS

Attachment A - Well Sampling Data Sheet
Attachment B - Purging Equipment Selection

ATTACHMENT A
SAMPLE LOG SHEET

NUS CORPORATION
A Halliburton Company

SAMPLE LOG SHEET

☐ Monitoring Well Data
☐ Domestic Well Data
☐ Other ________

Page _____ of _____

Case # __________

By __________

Project Site Name ____________________ Project Site Number ______________

NUS Source No. ________________ Source Location ________________

	Purge Data				
Total Well Depth:					
Well Casing Size & Depth	Volume	pH	S.C.	Temp. (°C)	Color & Turbidity
Static Water Level:					
One Casing Volume					
Start Purge (hrs):					
End Purge (hrs.):					
Total Purge Time (min)					
Total Amount Purged (gal):					
Monitor Reading:					
Purge Method:					
Sample Method.					
Depth Sampled:					
Sample Date & Time:	Sample Data				
	pH	S.C.	Temp (°C)	Color & Turbidity	
Sampled By:					
Signature(s)	Observations / Notes:				

Type of Sample

☐ Low Concentration
☐ High Concentration
☐ Grab
☐ Composite
☐ Grab - Composite

Analysis:	Preservative		Organic	Inorganic
		Traffic Report #		
		Tag #		
		AB #		
		Date Shipped		
		Time Shipped		
		Lab		
		Volume		

ATTACHMENT B
PURGING EQUIPMENT SELECTION

Purging Equipment Selection

Diameter Casing	Bailer	Peristaltic Pump	Vacuum Pump	Airlift	Diaphragm "Trash" Pump	Submersible Diaphragm Pump	Submersible Electric Pump	Submersible Electric Pump w/Packer
1.25-inch								
Water level <25 ft		X	X	X	X			
Water level >25 ft				X				
2-inch								
Water level <25 ft	X	X	X	X	X	X		
Water level >25 ft	X			X		X		
4-inch								
Water level <25 ft	X	X	X	X	X	X	X	X
Water level >25 ft	X			X		X	X	X
6-inch								
Water level <25 ft				X	X		X	X
Water level >25 ft				X			X	X
8-inch								
Water level <25 ft				X	X		X	X
Water level >25 ft				X			X	X

Manufacturer	Model name/ number	Principle of operation	Maximum outside diameter/length (inches)	Construction materials (w/lines & tubing)	Lift range (ft)	Delivery rates or volumes	1982 price (dollars)	Comments
BarCad Systems, Inc	BarCad Sampler	dedicated, gas drive (positive displacement)	1 5/16	PE, brass, nylon, aluminum oxide	0 150 with std tubing	1 liter for each 10-15 ft of submergence	220 350	requires compressed gas, custom sizes and materials available, acts as piezometer
Cole-Parmer Inst Co	Master Flex 7570 Portable Sampling Pump	portable, peristaltic (suction)	<1 0/NA	(not submersible) Tygon®, silicone Viton®	0-30	670 mL/min with 7015-20 pump head	500-600	AC/DC, variable speed control available, other models may have different flow rates
ECO Pump Corp.	SAMPLifier	portable, venturi	<1 5 or <2 0/NA	PP, PE, PVC, SS, Teflon®, Tefzel®	0-100	0-500 mL/min depending on lift	400 700	AC, DC, or gasoline driven motors available, must be primed
Galtek Corp.	Bailer 219-4	portable, grab (positive displacement)	1 66/38	Teflon®	no limit	1076 mL	120-135	other sizes available
GeoEngineering, Inc.	GEO-MONITOR	dedicated; gas drive (positive displacement)	1 5/16	PE, PP, PVC, Viton®	probably 0-150	app 1 liter for each 10 ft of submergence	185	acts as piezometer, requires compressed gas
Industrial and Environmental Analysts, Inc (IEA)	Aquarius	portable; bladder (positive displacement)	1 75/43	SS, Teflon®, Viton®	0-250	0-2800 mL/min	1500-3000	requires compressed gas, other models available; AC, DC, manual operation possible
IEA	Syringe Sampler	portable, grab (positive displacement)	1 75/43	SS, Teflon®	no limit	850 mL sample vol.	1100	requires vacuum and/or pressure from hand pump
Instrument Specialties Co. (ISCO)	Model 2600 Well Sampler	portable; bladder (positive displacement)	1 75/50	PC, silicone, Teflon®, PP, PE, Delrin® acetal	0-150	0-7500 mL/min	990	requires compressed gas (40 psi minimum)
Keck Geophysical Instruments, Inc.	SP-81 Submersible Sampling Pump	portable, helical rotor (positive displacement)	1.75/25	SS, Teflon®, PP, EPDM, Viton®	0-160	0-4500 mL/min	3500	DC operated
Leonard Mold and Die Works, Inc.	GeoFilter Small Dia Well Pump (#0500)	portable; bladder (positive displacement)	1 75/38	SS, Teflon®, PC, Neoprene®	0-400	0-3500 mL/min	1400-1500	requires compressed gas (55 PSI minimum); pneumatic or AC/DC control module
Oil Recovery Systems, Inc.	Surface Sampler	portable, grab (positive displacement)	1 75/12	acrylic, Delrin®	no limit	app 250 mL	125-160	other materials and models available, for measuring thickness of "floating" contaminants
Q E D Environmental Systems, Inc	Well Wizard® Monitoring System (P 100)	dedicated, bladder (positive displacement)	1 66/36	PVC	0-230	0 2000 mL/min	300-400	requires compressed gas, piezometric level indicator, other materials available

Source: Barcelona et al., 1983

Manufacturer	Model name/number	Principle of operation	Maximum outside diameter/length (inches)	Construction materials (w/lines & tubing)	Lift range (ft)	Delivery rates or volumes	1982 price (dollars)	Comments
Randolph Austin Co	Model 500 Vari Flow Pump	portable, peristaltic (suction)	<0.5/N/A	(not submersible) rubber, Tygon®, or Neoprene®	0-30	see comments	1200-1300	flow rate dependent on motor and tubing selected, AC operated, other models available
Robert Bennett Co.	Model 180	portable, piston (positive displacement)	1.8/22	SS, Teflon®, Delrin®, PP, Viton® acrylic, PE	0-500	0-1800 mL/min	2600-2700	requires compressed gas, water level indicator and flow meter, custom models available
Slope Indicator Co (SINCO)	Model 514124 Pneumatic Water Sampler	portable, gas drive (positive displacement)	1.9/18	PVC, nylon	0-1100	250 mL/flushing cycle	250-350	requires compressed gas, SS available, piezometer model available, dedicated model available
Solinst Canada Ltd	5W Water Sampler	portable, grab (positive displacement)	1.9/27	PVC, brass, nylon, Neoprene®	0-330	500 mL	1300-1800	requires compressed gas, custom models available
TIMCO Mfg. Co., Inc.	Std. Bailer	portable; grab (positive displacement)	1.66/custom	PVC, PP	no limit	250 mL/ft of bailer	20-60	other sizes, materials, models available, optional bottom-emptying device available, no solvents used
TIMCO	Air or Gas Lift Sampler	portable, gas drive (positive displacement)	1.66/30	PVC, Tygon®, Teflon®	0-150	350 mL/flushing cycle	100-200	requires compressed gas, other sizes, materials, models available, no solvents used
Tole Devices Co	Sampling Pump	portable, bladder (positive displacement)	1.38/48	SS, silicone, Delrin®, Tygon®	0-125	0-4000 mL/min	800-1000	compressed gas required, DC control module, custom built

Construction Materials Abbreviations

PE	Polyethylene
PP	Polypropylene
PVC	Polyvinyl Chloride
SS	Stainless Steel
PC	Polycarbonate
EPDM	Ethylene-Propylene Diene (synthetic rubber)

Other Abbreviations

NA	Not Applicable
AC	Alternating Current
DC	Direct Current

NOTE. Other manufacturers market pumping devices which could be used for ground water sampling, though not expressly designed for this purpose. The list is not meant to be all-inclusive and listing does not constitute endorsement for use. Information in the table is from sales literature and/or personal communication. No skimmer, scavenger type, or high-capacity pumps are included.

Source: Barcelona et al., 1983

NUS CORPORATION ENVIRONMENTAL MANAGEMENT GROUP	STANDARD OPERATING PROCEDURES	Number: SA-6.2 Page: 1 of 12 Effective Date: 05/04/90 Revision: 2 Applicability: EMG Prepared: Earth Sciences Approved: D. Senovich
Subject: SAMPLE PACKAGING AND SHIPPING		

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1.0 PURPOSE

This procedure provides instruction for sample packaging and shipping in accordance with U.S. Department of Transportation (DOT) regulations.

2.0 SCOPE

Samples collected at hazardous waste sites usually have to be transported elsewhere for analysis. This requires that the samples be appropriately preserved to prevent or minimize chemical alteration prior to analysis, and be transported to protect their integrity, as well as to protect against any detrimental effects from leakage or breakage. Regulations for packaging, marking, labeling, and shipping hazardous materials and wastes are promulgated by the U.S. Department of Transportation and described in the Code of Federal Regulations (49 CFR 171 through 177, in particular 172.402h, Packages Containing Samples). In general, these regulations were not intended to cover shipment f samples collected at controlled or uncontrolled hazardous waste sites or samples collected during emergency responses. However, the EPA has agreed through a memorandum of agreem nt to package, mark, label, and ship samples observing DOT procedures. The information presented h re is for general guidance.

This procedure is applicable to all samples taken from uncontrolled hazardous substance sites for analysis at laboratories away from the site.

3.0 GLOSSARY

Carrier - A person or firm engaged in the transportation of passengers or property.

Hazardous Material - A substance or material in a quantity and form which may pose an unreasonabl risk to health and safety or property when transported in commerce ("commerce" here to includ any traffic or transportation). Defined and regulated by DOT (49 CFR 173.2) and listed in Attachm nt A of this guideline.

Hazardous Waste - Any substance listed in 40 CFR Subpart D (¥261.20 et seq) or otherwise characterized as ignitable, corrosive, reactive, or EP toxic as specified under 40 CFR Subpart C (¥261.20 et seq) that would be subject to manifest requirements specified in 40 CFR 262. D fin d and regulated by EPA.

Marking - Applying the descriptive name, instruction, cautions, weight, or specification marks or combination thereof required to be placed outside containers of hazardous materials.

n.o.i. - Not otherwise indicated.

n.o.s. - Not otherwise specified.

ORM - Other regulated material.

Packaging - The assembly of one or more containers and any other components necessary t assure compliance with the minimum packaging requirements of 49 CFR 174, including containers (ther than freight containers or overpacks), portable tanks, cargo tanks, tank cars, multiunit tank car tanks.

Placard - Color-coded, pictorial sign depicting the hazard class symbol and name to b placed on all four sides of a vehicle transporting certain hazardous materials.

Reportable Quantity (RQ) - A parenthetical note of the form "(RQ-1000/454)" following an entry in the DOT Hazardous Materials table (49 CFR 172.101) indicates the reportable quantity of the substance in pounds and kilograms. If a spill of that amount or more of the substance occurs during transit or storage, a report must be filed with DOT according to ¥171.15-15 concerning hazardous materials incidents reports. If the material spilled is a hazardous waste, a report must always be filed, regardless of the amount, and must include a copy of the manifest. If the RQ notation appears, it must be shown either immediately before or after the proper shipping name on the shipping paper (or manifest). Most shipping papers and manifests will have a column designated "HM" which may be used for this purpose.

4.0 RESPONSIBILITIES

Field Operations Leader or Team Sampling Leader - responsible for determining that samples are properly packaged and shipped.

Sampling Personnel - responsible for implementing the packaging and shipping requirements.

5.0 PROCEDURES

5.1 INTRODUCTION

Samples collected for shipment from a site shall be classified as either environmental or hazardous material (or waste) samples. In general, environmental samples are collected off-site (for example from streams, ponds, or wells) and are not expected to be grossly contaminated with high levels of hazardous materials. On-site samples (for example, soil, water, and materials from drums or bulk storage tanks, obviously contaminated ponds, lagoons, pools, and leachates from hazardous waste sites) are considered hazardous. A distinction must be made between the two types of sampl s in order to:

- Determine appropriate procedures for transportation of samples. If there is any doubt, a sample shall be considered hazardous and shipped accordingly.
- Protect the health and safety of laboratory personnel receiving the samples. Special precautions are used at laboratories when samples other than environmental sampl s are received.

5.2 ENVIRONMENTAL SAMPLES

5.2.1 Packaging

Envir nmental samples may be packaged following the procedures outlined in Section 5.4 for samples classified as "flammable liquids" or "flammable solids." Requirements for marking, labeling, and shipping papers do not apply.

Environmental samples may also be packed without being placed inside metal cans as required for flammable liquids or solids.

- Place sample container, properly identified and with a sealed lid, in a polyethylene bag, and seal the bag.
- Place sample in a fiberboard container or metal picnic cooler which has been lined with a large polyethylene bag.
- Pack with enough noncombustible, absorbent, cushioning materials to minimize the possibility of the container breaking.
- Seal large bag.
- Seal or close outside container.

5.2.2 Marking Labeling

Sample containers must have a completed sample identification tag and the outside container must be marked "Environmental Sample." The appropriate side of the container must be marked "This End Up" and arrows placed appropriately. No DOT marking or labeling are required.

5.2.3 Shipping Papers

N DOT shipping papers are required. However, the appropriate chain-of-custody forms must be included with the shipment.

5.2.4 Transportation

There are no DOT restrictions on mode of transportation.

5.3 DETERMINATION OF SHIPPING CLASSIFICATION FOR HAZARDOUS MATERIAL SAMPLES

Samples not determined to be environmental samples, or samples known or expected to contain hazardous materials, must be considered hazardous material samples and transported according to the requirements listed below.

5.3.1 Known Substances

If the substance in the sample is known or can be identified, package, mark, label and ship according to the specific instructions for that material (if it is listed) in the DOT Hazardous Materials Table, 49 CFR 172.101.

Unz and Company have published the following steps to help in locating a proper shipping name from the Hazardous Materials Table, 49 CFR 172.101.

1. Look first for the chemical or technical name of the material, for example, ethyl alcohol Note that many chemicals have more than one technical name, for example, perchloroethylene (not listed in 172.101) is also called tetrachloroethylene (listed 172.101). It may b useful to consult a chemist f r all possible technical names a material can have. If your material is not listed by its technical name then. . . . . .

2. Look for the chemical family name. For example, pentyl alcohol is not listed but the chemical family name is: alcohol, n.o.s. (not otherwise specified). If the chemical family name is not listed then. . . . .

3. Look for a generic name based on end use. For example, Paint, n.o.s or Fireworks, n.o.s. If a generic name based on end use is not listed then. . . . .

4. Look for a generic family name based on end use, for example, drugs, n.o.s. or cosmetics, n.o.s. Finally, if your material is not listed by a generic family name but you suspect or know the material is hazardous because it meets the definition of one or more hazardous classes, then. . . . . . .

5. You will have to go the the general hazard class for a proper shipping name. For example, Flammable Liquid, n.o.s, or Oxidizer, n.o.s.

5.3.2 Unknown Substances

For samples of hazardous substances of unknown content, select the appropriate transp rtation category according to the DOT Hazardous Materials Classification (Attachment A), a priority system of transportation categories.

The correct shipping classification for an unknown sample is selected through a process of elimination, utilizing Attachment A. Unless known or demonstrated otherwise (through the us of radiation survey instruments), the sample is considered radioactive and appropriate shipping regulations for "radioactive material" followed.

If a radioactive material is eliminated, the sample is considered to contain "Poison A" materials (Attachment B), the next classification on the list. DOT defines "Poison A" as extremely dangerous p isonous gases or liquids of such a nature that a very small amount of gas, or vapor of the liquids, mixed with air is dangerous to life. Most Poison A materials are gases or compressed gases and would not be found in drum-type containers. Liquid Poison A would be found only in closed containers; however,all samples taken from closed drums do not have to be shipped as Poison A, which provides for a "worst case" situation. Based upon information available, a judgment must be made whether a sample from a closed container is a Poison A.

If Poison A is eliminated as a shipment category, the next two classifications are "flammable" or "n nflammable" gases. Since few gas samples are collected, "flammable liquid" would be the next applicable category. With the elimination of radioactive material, Poison A, flammable gas, and nonflammable gas, the sample can be classified as flammable liquid (or solid) and shipped accordingly. These procedures would also suffice for shipping any other samples classified below flammable liquids in the DOT classification table (Attachment A). For samples containing unkn wn materials, categories listed below flammable liquids/solids on Attachment A are generally not used because showing that these materials are not flammable liquids (or solids) requires flashpoint testing, which may be impractical and possibly dangerous at a site. Thus, unless the sample is kn wn to consist of materials listed as less hazardous than flammable liquid (or solid) on Attachment A, it is considered a flammable liquid (or solid) and shipped as such.

F r any hazardous material shipment, utilize the shipping checklist (Attachment C) as a guideline to ensure that all sample-handling requirements are satisfied.

5.4 PACKAGING AND SHIPPING OF SAMPLES CLASSIFIED AS FLAMMABLE LIQUID (OR SOLID)

5.4.1 Packaging

Applying the word "flammable" to a sample does not imply that it is in fact flammable. The word prescribes the class of packaging according to DOT regulations.

1. Collect sample in the prescribed container with a nonmetallic, Teflon-lined screw cap. To prevent leakage, fill container no more than 90 percent full.

2. Complete sample label and sample identification tag and attach securely to sampl container.

3. Seal container and place in 2-mil thick (or thicker) polyethylene bag, one sample per bag. Position sample identification tag so that it can be read through bag. Seal bag.

4. Place sealed bag inside metal can and cushion it with enough noncombustible, absorbent material (for example, vermiculite or diatomaceous earth) between the bottom and sides of the can and bag to prevent breakage and absorb leakage. Pack one bag per can. Use clips, tape, or other positive means to hold can lid securely, tightly and permanently. Mark can as indicated in Paragraph 1 of Section 5.4.2, below.

5. Place one or more metal cans (or single 1-gallon bottle) into a strong outside c ntainer, such as a metal picnic cooler or a DOT-approved fiberboard box. Surround cans with noncombustible, absorbent cushioning materials for stability during transport. Mark container as indicated in Paragraph 2 of Section 5.4.2.

5.4.2 Marking/Labeling

1. Use abbreviations only where specified. Place the following information, either hand-printed or in label form, on the metal can (or 1-gallon bottle):

   - Laboratory name and address.

   - "Flammable Liquid, n.o.s. UN1993" or "Flammable Solid, n.o.s. UN1325."

N t therwise specified (n.o.s) is not used if the flammable liquid (or solid) is identified. Th n the name of the specific material is listed before the category (for example, Acetone, Flammable Liquid), followed by its appropriate UN number found in the DOT Hazardous Materials table (49 CFR 172.101).

2. Place all information on outside shipping container as on can (or bottle), specifically:

   - Proper shipping name.
   - UN or NA number.
   - Proper label(s).
   - Addressee and sender.

   Place the following labels on the outside shipping container: "Cargo Aircraft Only" and "Flammable Liquid" (or "Flammable Solid"). "Dangerous When Wet" label shall be used if the solid has not b en exposed to a wet environment. "Laboratory Samples" and "THIS SIDE UP" or "THIS END UP" shall also b mark d on the top of the outside container, and upward-pointing arrows shall be placed on all f ur sides of the container.

5.4.3 Shipping Papers

1. Use abbreviations only where specified. Complete the carrier-provided bill of lading and sign certification statement (if carrier does not provide, use standard industry form, see Attachment D). Provide the following information in the order listed (one form may be used for more than one exterior container).

   - "Flammable Liquid, n.o.s. UN1993" or "Flammable Solid, n.o.s. UN1325."
   - "Limited Quantity" (or "Ltd. Qty.").
   - "Cargo Aircraft Only."
   - Net weight (wt) or net volume (vol), just before or just after "Flammable Liquid, n.o.s." or "Flammable Solid, n.o.s.," by item, if more than one metal can is inside an exterior container.
   - "Laboratory Samples" (if applicable).

2. Include Chain-of-Custody Record, properly executed in outside container.

3. "Limited Quantity" of "Flammable Liquid, n.o.s." is limited to one pint per inner container. For "Flammable Solid, n.o.s.," net weight of inner container plus sample shall not exceed one pound; total package weight shall not exceed 25 pounds.

5.4.4 Transportation

1. Transport unknown hazardous substance samples classified as flammable liquids by rented or common carrier truck, railroad, or express overnight package services. Do not transport by any passenger-carrying air transport system, even if they have cargo-only aircraft. DOT regulations permit regular airline cargo-only aircraft, but difficulties with most suggest avoiding them. Instead, ship by airline carriers that only carry cargo.

2. For transport by government-owned vehicle, including aircraft, DOT regulations do not apply. However, procedures described above, with the exception of execution of th bill of lading with certification, shall still be used.

6.0 REFERENCES

U.S. Department of Transportation, 1983. Hazardous Materials Regulations, 49 CRF 171-177.

NUS Standard Operating Procedure SA-6.1 - Sample Identification and Chain-of-Custody

NUS Standard Operating Procedure SA-1.2 - Sample Preservation

NUS Standard Operating Procedure SF-1.5 - Compatibility Testing

7.0 ATTACHMENTS

Attachment A - DOT Hazardous Material Classification (49 CFR 173.2)
Attachment B - DOT List of Class "A" Poisons (49 CFR 172.101)
Attachment C - Hazardous Materials Shipping Checklist
Attachment D - Standard Industry Certification Form

ATTACHMENT A

DOT HAZARDOUS MATERIAL CLASSIFICATION (49 CFR 173.2)

1. Radioactive material (except a limited quantity)
2. Poison A
3. Flammable gas
4. Nonflammable gas
5. Flammable liquid
6. Oxidizer
7. Flammable Solid
8. Corrosive material (liquid)
9. Poison B
10. Corrosive material (solid)
11. Irritating material
12. Combustible liquid (in containers having capacities exceeding 110 gallons [416 liters])
13. ORM-B
14. ORM-A
15. Combustible liquid (in containers having capacities of 110 gallons [416 liters] or less)
16. ORM-E

ATTACHMENT B

DOT LIST OF CLASS "A" POISON (49 CFR 172.101)

Material	Physical State at Standard Temperature
Arsine	Gas
Bromoacetone	Liquid
Chloropicrin and methyl chloride mixture	Gas
Chloropicrin and nonflammable,nonliquefied compressed gas mixture	Gas
Cyanogen chloride	Gas (> 13.1°C)
Cyanogen gas	Gas
Gas identification set	Gas
Gelatin dynamite (H. E. Germaine)	----
Grenade (with Poison "A" gas charge)	----
Hexaethyl tetraphosphate/compressed gas mixture	Gas
Hydrocyanic (prussic) acid solution	Liquid
Hydrocyanic acid, liquefied	Gas
Insecticide (liquefied) gas containing Poison "A" or Poison "B" material	Gas
Methyldichloroarsine	Liquid
Nitric oxide	Gas
Nitrogen peroxide	Gas
Nitrogen tetroxide	Gas
Nitrogen dioxide, liquid	Gas
Parathion/compressed gas mixture	Gas
Phosgene (diphosgene)	Liquid

ATTACHMENT C
HAZARDOUS MATERIALS SHIPPING CHECKLIST

PACKAGING

1. Check DOT 172.500 table for appropriate type of package for hazardous substance
2. Check for container integrity, especially the closure.
3. Check for sufficient absorbent material in package.
4. Check for sample tags and log sheets for each sample, and chain-of-custody record.

SHIPPING PAPERS

1. Check that entries contain only approved DOT abbreviations.
2. Check that entries are in English.
3. Check that hazardous material entries are specially marked to differentiate them from any nonhazardous materials being sent using same shipping paper.
4. Be careful all hazardous classes are shown for multiclass materials.
5. Check total amounts by weight, quantity, or other measures used.
6. Check that any limited-quantity exemptions are so designated on the shipping paper.
7. Offer driver proper placards for transporting vehicle.
8. Check that certification is signed by shipper.
9. Make certain driver signs for shipment.

RCRA MANIFEST

1. Check that approved state/federal manifests are prepared.
2. Check that transporter has the following: valid EPA identification number, valid driver's license, valid vehicle registration, insurance protection, and proper DOT labels for materials being shipped.
3. Check that destination address is correct.
4. Check that driver knows where shipment is going.
5. Check that the driver is aware of emergency procedures for spills and accidents.
6. Make certain driver signs for shipment
7. Make certain one copy of executed manifest and shipping document is retained by shipper.

ATTACHMENT D

STANDARD INDUSTRY CERTIFICATION FORM

NO PCS	SIZE	GROSS WEIGHT	H M	D O T PROPER SHIPPING NAME	HAZARD CLASS	CODE	[illegible]	CONTAINER NUMBERS	PLC	BULK
1	55 gal	200 lbs.	x	Nitric Acid, Fuming	Oxidizer	SS-BN	C	1	✓	
1	55 gal	450 lbs.	x	Flammable Liquid, n.o.s.	Flammable Liquid	SS-ABF	—	2		✓
1	55 gal	250 lbs.	x	Flammable liquid, n.o.s.	Flammable Liquid	SS-BN	B	3	✓	
1	15 A	12 lbs.	x	Bromine	Corrosive Material	SS-BN	C	4	✓	

SHIPPER'S CERTIFICATION
This is to certify that the above named materials are properly classified, described, packaged, marked and labeled and are in proper condition for transportation according to the applicable regulations of the Department of Transportation.

Shipper's Signature

Placards Req'd

Shipment Date   Manifest No

Disposal Work Order

Service Order No

 Rev 1-79

D334901

NUS CORPORATION ENVIRONMENTAL MANAGEMENT GROUP	STANDARD OPERATING PROCEDURES	Number SA-6.3	Page 1 of 4
		Effective Date 05/04/90	Revision 2
		Applicability EMG	
		Prepared Earth Sciences	
Subject SITE LOGBOOK		Approved D. Senovich	

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1.0 PURPOSE

This procedure describes the process for keeping a site logbook.

2.0 SCOPE

The site logbook is a controlled document which records all major on-site activities during a Remedial Investigation/Feasibility Study. At a minimum, the following activities/events shall be recorded in the site logbook:

- Arrival/departure of site visitors
- Arrival/departure of equipment
- Sample pickup (chain-of-custody form numbers, carrier, time)
- Sampling activities/sample logsheet numbers
- Start or completion of borehole/trench/monitoring well installation or sampling activiti s
- Health and Safety issues

Th site logbook is initiated at the start of the first on-site activity (e.g., initial reconnaissance surv y). Entries are made for every day that on-site activities take place which involve RI/FS contract r personnel. One current site logbook is maintained per site.

The site logbook becomes part of the permanent site file maintained in the RI contractor's office. Because information contained in the site logbook may be admitted as evidence in cost recovery or other legal proceedings, it is critical that this document be properly maintained.

3.0 GLOSSARY

Sit Logbook - The logbook is a bound notebook with consecutively numbered pages that cannot be removed. Upon entry of data, the logbook requires signature by the responsible site leader (see Section 5.1).

4.0 RESPONSIBILITIES

The site logbook is issued by the Regional Manager (or his designee) to the Site Manager f r th duration of the project. The Site Manager releases the site logbook to the Field Operations Leader or other person responsible for the direction of on-site activities (e.g., Reconnaissance Survey T am Leader, Sampling Team Leader). It is the responsibility of this person (or his designee) to keep the sit logbook current while in his possession, and return it to the Site Manager or turn it over to another field team. Following the completion of all fieldwork, the site logbook is returned to the Site Manager for inclusion in the permanent site files.

5.0 PROCEDURES

5.1 GENERAL

The cover of each site logbook contains the following information:

- Project Name
  NUS Project Numb r
  RI/FS Contractor and Site Manager's Name
  Sequ ntial Book Number

- Start Date
  End Date

Daily entries into the logbook may contain a variety of information. At the beginning of each day the following information must be recorded:

  Date
- Start time
- Weather
  All field personnel present
  Any visitors present

During the day, a summary of all site activities and level of personal protection shall be recorded in the logbook. The information need not duplicate that recorded in other field notebooks (e.g., sample logbook, Site Geologist's notebook, Health and Safety Officer's notebook, etc.), but shall summarize the contents of these other notebooks and refer to the page locations in these notebooks for detailed information. An example of a site logbook page is shown in Attachment A.

The sample logsheet for each sample collected (see Procedure SA-6.6) must be referenced. If m asurements are made at any location, the measurements and equipment used must either be rec rded in the site logbook or reference must be made to the notebook and page number(s) on which they are recorded (see Attachment A).

All entries shall be made in black pen. No erasures are permitted. If an incorrect entry is made, the data shall be crossed out with a single strike mark, and initialed and dated. At the completion of entries by any individual, the logbook must be signed. It must also be signed by the Field Operations Leader or responsible site leader at the end of each day.

5.2 PHOTOGRAPHS

When movies, slides, or photographs are taken of a site or any monitoring location, th y are numbered to correspond to logbook entries. The name of the photographer, date, time, site location, site description, and weather conditions are entered in the logbook as the photographs are taken. A series entry may be used for rapid-sequence photographs. The photographer is not required to record the aperture settings and shutter speeds for photographs taken within the normal automatic exposure range. However, special lenses, films, filters, and other image-enhancement techniques must be noted in the logbook. If possible, such techniques shall be avoided, since they can adversely affect the admissibility of photographs as evidence. Chain-of-custody procedures depend upon the subject matter, type of film, and the processing it requires. Film used for aerial photography, confidential information, or criminal investigation require chain-of-custody procedures. Adequate logbook notation and receipts may be used to account for routine film processing. Once processed, the slides of photographic prints shall be serially numbered and labeled according to the logbook descriptions.

6.0 REFERENCES

None.

7.0 ATTACHMENTS

Attachment A - Typical Site Logbook Entry

ATTACHMENT A
TYPICAL SITE LOGBOOK ENTRY

START TIME: ______________ DATE: ______________

SITE LEADER: ______________________
PERSONNEL:

NUS	DRILLER	EPA

WEATHER: Clear, 68°F, 2-5 mph wind from SE

ACTIVITIES:

1. Steam jenney and fire hoses were set up.

2. Drilling activities at well _______ resumes. Rig geologist was ____________________. See Geologist's Notebook, No. 1, page 29-30, for details of drilling activity. Sampl No. 123-21-S4 collected; see sample logbook, page 42. Drilling activities completed at 11:50 and a 4 inch stainless steel well installed. See Geologist's Notebook, No. 1, page 31, and well construction details for well __________.

3. Drilling rig No. 2 steam-cleaned at decontamination pit. Then set up at location of well __________.

4. Well __________ drilled. Rig geologist was ____________________. See Geologist's Notebook, No. 2, page ______ for details of drilling activities. Sample numbers 123-22-S1, 123-22-S2, and 123-22-S3 collected; see sample logbook, pages 43, 44, and 45.

5. Well _________ was developed. Seven 55-gallon drums were filled in the flushing stage. The well was then pumped using the pitcher pump for 1 hour. At the end of the hour, water pumped from well was "sand free."

6. EPA remedial project manger arrives on-site at 14:25 hours.

7. Large dump truck arrives at 14:45 and is steam-cleaned. Backhoe and dump truck set up over test pit ______________.

8. Test pit ___________ dug with cuttings placed in dump truck. Rig geologist was ____________________. See Geologist's Notebook, No. 1, page 32, for details f test pit activities. Test pit subsequently filled. No samples taken for chemical analysis. Due to shallow groundwater table, filling in of test pit _____ resulted in a very soft and wet area. A mound was developed and the area roped off.

9. Express carrier picked up samples (see Sample Logbook, pages 42 through 45) at 17:50 hours. Site activities terminated at 18:22 hours. All personnel offsite, gate locked.

____
Field Operations Leader

EMSR STANDARD OPERATING PROCEDURE

Number: 7600 **Date of Issue:** 1st Quarter, 1984

Title: Decontaminati n of Equipment

Organizational Acceptance	Authorization	Date
Originator	Charles S Martin	3/2/84
Department Manager	Arthur L Evans	3/2/84
Divisional Manager	Elaine Moore	3-2-84
Group Quality Assurance Officer	Kent W. Whitemond	3/2/84
Other		

Revisions	Changes	Authorization	Date
1	Update	SMW CEM AGL EHM	3/2/84 3/2/84 3/2/84 3-2-84
2	• Addition of Health and Safety Considerations, Quality Assurance Planning Considerations, Training Requirements, QA/QC Checks and Documentation Sections. • Addition of nitric acid wash for metals analyses. • Addition of heavy equipment decontamination protocol. • Miscellaneous edits and updates.	CEM KWF Mike Dbrowski	3/12/90 4/3/90 5/3/90

1.0 General Applicability

This SOP describes the methods to be used for the decontamination f all field equipment which may become contaminated or act as a contamination source during a sample collection task. The equipment may include split-spoon samplers, bailers, trowels, shipping coolers, drill rigs, backhoes, or any other type of equipment used during field activities.

Decontamination is performed as a quality assurance measure and a safety precaution. Improperly decontaminated sampling equipment can lead to misinterpretation of environmental data due to interference caused by cross-contamination. Decontamination protects field personnel from hazardous materials and protects the community by preventing uncontrolled transportation of contaminants from a site.

Decontamination is accomplished by manually scrubbing, washing, or spraying equipment with detergent solutions, tap water, distilled/deionized water, steam, or solvents. Equipment will be allowed to air dry after being decontaminated or may be wiped dry with chemical-free paper towels if immediate use is necessary. The decontamination method and agents are to be determined on a project-specific basis and must be stated in the Quality Assurance Project Plan (QAPP).

The frequency of equipment use dictates that most decontamination be accomplished at each sampling site between collection points. Decontamination waste products such as liquids, solids, rags, gloves, etc., will be collected and disposed of as specified in the QAPP. All cleaning materials and wastes should be stored in a central location so as to maintain control over the quantity of materials used or produced throughout the study.

2.0 Definitions

Not applicable

3.0 Health and Safety Considerations

Decontamination procedures may involve chemical exposure hazards associated with the medium being explored or solvents employed and may involve physical hazards associated with decontamination equipment. When decontamination is performed on equipment which has been in contact with hazardous materials or when the quality assurance objectives of the project require decontamination with chemical solvents, the measures necessary to protect personnel must be addressed in the project Health and Safety Plan. This plan must be approved by the project Health and Safety Officer before work commences, must be distributed to all personnel performing equipment decontamination, and must be adhered to as field activities are performed.

4.0 Quality Assurance Planning Considerations

The decontamination method, solvent, frequency, location on site and the method of containment and disposal of decontamination wash solids and solutions are dependent on site logistics, site-specific chemistry, the nature of the contaminated media to be studied and the objectives of the study. In addition, some state and local agencies have specific requirements for decontamination. Each topic must be considered and addressed during the formulation of a decontamination strategy and should be outlined in the Quality Assurance Project Plan (QAPP).

The ideal situation would be to have all sampling equipment such as bailers, trowels and shovels laboratory decontaminated and dedicated to one sampling location for each day of sampling. Laboratory decontamination may not be a practical option, however, depending n the scope of the project. It may be to expensive to obtain laboratory decontaminated sampling devices for short-term projects or projects which have numerous sampling locations. Sampling equipment such as split-spoon samplers or hand augers are too large to have laboratory cleaned. Finally, it may be difficult to schedule the necessary laboratory procedures.

There are several factors which need to be considered when deciding upon a decontamination solvent. Obviously the solvent should not be an analyte of interest. It must be relatively stable so that it can be handled and stored in the field without special handling requirements. All sampling equipment must be resistant to the solvent. The solv nt must be evaporative or water soluble or preferably both. State or local agencies may have specific requirements regarding decontaminati n solvents.

The analytical objectives of the study must also be considered when deciding upon a decontamination solvent. Methanol is the solvent f choice for general organic analyses. It is relatively safe and effective. A 10% nitric acid in deionized water solution is the solvent of choice for general metals analyses. Nitric acid can be used only on Teflon, plastics and glass. If used on metal equipment, nitric acid will eventually corrode the metal and lead to the introduction of metals to the collected samples. If it is necessary to use metal sampling equipment for metals sampling, the procedure for decontamination will be a non-phosphate detergent wash followed by a tap water rinse and then a double distilled/deionized water rinse. State or local agencies may take exception to this procedure and require an acid wash. If this is the case, it must be recognized that the use of nitric acid on metal sampling equipment may lead to analytical interferences.

If it is determined that methanol or nitric acid are not adequate decontamination solvents for a particular project, it is strongly recommended that the local Regional QA Officer be consulted when selecting an alternative solvent.

Decontamination should be performed far enough away from the source of contamination so as not to be affected by the source but close enough to the sampling site to keep handling to a minimum. If heavy equipment such as drill rigs or backhoes are to be decontaminated, then a central decontamination station should be considered. Power may be requir d to run steam generators or high pressure water pumps. A source of water may also be necessary.

Depending on the nature of the contaminated media or the decontamination solvents utilized, it may be necessary to collect and dispose of all particulate matter and wash solutions. If containment is necessary it may be achieved by performing the decontamination in large galvanized tubs or over plastic sheeting. If heavy equipment is involved it may require the construction of a sealed concrete pad with drains and walls, or other suitable temporary structure, to contain sprays and splashes. Rinse and wash solutions should be collected and contained in 55 gallon metal or plastic drums. Upon review of the analytical data generated from the samples, the proper method of disposal of these waste products will be determined.

Procedures for Quality Control checks are outlined in Section 9.0.

5.0 Responsibilities

It is the responsibility of the project manager to ensure that the proper decontamination procedures are followed and that all waste products of decontamination are properly stored and disposed.

It is the responsibility of the project safety officer to design and effect safety measures which provide the best protection for all persons involved directly with sampling and/or decontamination.

It is the responsibility of any subcontractors (i.e., drilling contractors) to follow the proper, designated decontamination procedures that are stated in their contracts and outlined in the project QA and/or Health and Safety Plan.

It is the responsibility of all personnel involved with sample collection or decontamination to adhere to the decontamination requirements and procedures in this SOP and in project specific Health and Safety Plans and QA plans, to maintain a clean working environment and to ensure that contaminants are not negligently introduced to th environment.

6.0 Training/Qualifications

All field technicians performing decontamination procedures for an ENSR project must be properly trained in the decontamination procedures employed, the project data quality objectives, health and safety procedures and the project QA procedures. Specific training or orientation will be provided for each project to ensure that personnel understand the special circumstances and requirements of that proj ct.

7.0 Required Materials

- Decontamination agents may include: LIQUI-NOX or other phosphate-free biodegradable detergent solutions, tap water, distilled/deionized water, nitric acid, methanol, isopropanol, acetone or other appropriate solvent as specified in the QAPP.
- Personal protective equipment (defined in project Health and Safety Plan)
- Chemical-free paper towels
- Disposable gloves
- Waste storage containers: drums, boxes, plastic bags
- Cleaning containers: plastic buckets, galvanized steel pans, plastic (nalgene or equivalent) upright cylinder
- Cleaning brushes
- High pressure water or steam generator (if necessary)
- Plastic sheeting
- Plastic water storage containers

8.0 Methods

8.1 General Procedures

8.1.1 The purpose of decontamination is three-fold. The first is to ensure that any compounds or contaminants which have been determined through chemical analyses to be present in a sample are in fact native to the sample. All sampling equipment such as bailers, trowels, shovels, tape measures, split-spoon samplers, dredges, sample containers, sample shipment coolers, etc., must be decontaminated before use to ensure that contaminants have not been introduced t th sample during the sampling process.

The second purpose of decontamination is to minimize th exposure of sampling personnel to hazardous materials.

The third purpose of decontamination is to prevent the introduction of new contaminants to a sampling site or prevent the transportation of compounds or contaminants from the site. Heavy equipment such as trucks, drilling rigs and backhoes should be decontaminated upon arrival at the site to prevent the introduction of road chemicals or contaminants from a previous site. Monitoring well ris r pipes, screens and drilling augers must also be decontaminated to prevent the introduction of contaminants.

It should be assumed that all sampling equipment, including gloves, are contaminated until the proper decontamination procedures have been performed on them and that contaminated equipment can lead to invalid analytical results.

8.1.2 Unless the decontaminated equipment or construction materials are to be used immediately, they should be wrapped in aluminum foil, shiny side out, and stored in a designated "clean" area. Field equipment can also be stored in plastic bags to eliminate the potential for contamination. Field equipment should be inspected and decontaminated prior to use if the equipment has been stored for long periods of time. Unless customized procedures are stated in the QAPP (see Section 4.0), th standard procedures specified below shall be followed.

8.2 Decontamination for Organic Analyses

8.2.1 Determine from the QAPP the method of containment for the particulate and wash solution products of decontamination. Typically, smaller, more manageable equipment will be decontaminated in a plastic or galvanized tub. The brush and container used for the decontamination process sh uld be treated in the same manner as sampling equipment in steps 8.2.2 through 8.2.10.

8.2.2 Decontamination is to be performed before sampling events and between sampling points.

8.2.3 Remove all solid particles from the equipment or material by brushing and then rinsing with available tap water. This initial step is performed to remove gross contamination. Depending on the size of the equipment being decontaminated, this may be preceded by a steam r high pressure water rinse to remove solids and/or residual oil or grease. See Section 8.5 for decontamination of heavy equipment.

8.2.4 Wash the equipment or sampler with LIQUI-NOX or other phosphate-free detergent solution.

8.2.5 Rinse with tap water or distilled/deionized water until all detergent and other residue is washed away. Rerinse if necessary or repeat previous steps as necessary.

8.2.6 Rinse with methanol or other appropriate solvent. The solvent to be used should be specified in the QAPP.

8.2.7 Rinse with deionized water to remove any residual solv nt.

8.2.8 Allow the equipment or material to air-dry in a clean area or wipe with chemical-free paper towels before use.

8.2.9 Dispose of soiled materials and wash solutions in the designated disposal containers.

8.3 Decontamination for Metals Analyses

8.3.1 For plastic and glass, follow the procedures outlined in 8.2, however, use a 10% nitric acid solution as the solvent rinse in step 8.2.7.

8.3.2 For metal equipment, follow steps 8.2.1 through 8.2.6 and allow the equipment or material to air dry in a clean area or wipe with chemical-free paper towels before use.

8.4 Decontamination of Submersible Pumps

8.4.1 This procedure will be used to decontaminate submersible pumps before and between ground-water sample collection points as well as the end of each day of use. If different pumps are used, consult the QAPP for specific decontamination procedures.

8.4.2 During decontamination the submersible pump will be placed on a decontaminated surface, such as a plastic sheet.

8.4.3 When removing the submersible pump from each well the power cord and discharge line will be wiped dry using chemical-free disposable towels. Should the pump be fitt d with a disposable discharge line, disconnect the line and dispose of it.

8.4.4 Clean an upright plastic-nalgene cylinder first with a methanol, 10% nitric acid or other specified solvent and then a distilled/deionized water rinse, wiping the free liquids after each.

8.4.5 For reversible pumps, reverse the pump to backwash all removable residual water present in the pump tubing. The pump should be shut off as soon as intermittent flow is observed from the reverse discharge.

8.4.6 Rinse the stainless steel submersible down hole pump section with a detergent solution followed by a water rinse and a liberal application of the specified solvent.

8.4.7 Place the submersible pump section upright in the cylinder and fill the cylinder with tap water, adding 50-100 ml f specified solvent for every one liter of water.

8.4.8 Activate the pump in the forward mode, withdrawing water from the cylinder.

8.4.9 Continue pumping until the water in the cylinder is pumped down and air is drawn through the pump. At this time air pockets will be observed in the discharge line. Shut off the pump immediately.

8.4.10 Remove the pump from the cylinder and place the pump in the reverse mode to discharge all removable water into a disposal container.

8.4.11 Using the water remaining in the cylinder, rinse the seal d portion of the power cord and discharge tube by pouring th water carefully over the coiled lines.

8.4.12 On reaching the next monitoring well, place the pump in th well casing and wipe dry both the power and discharge lines with a chemical-free paper towel as the pump is lowered.

8.5 Decontamination of Heavy Equipment

8.5.1 Upon arrival and prior to leaving a sampling site, all heavy equipment such as drill rigs, trucks, and backhoes should be thoroughly cleaned and then the parts of the equipment which come in contact or in close proximity to sampling activity should be decontaminated. This can be accomplished in two ways, steam cleaning or high pressur water wash and manual scrubbing. Following this initial cleaning, only those parts of the equipment which come in close proximity to the sampling activities must be decontaminated in between sampling events. This would include items such as the backhoe bucket and extension arm.

8.5.2 Consult the QAPP for instruction on the location of the decontamination station and the method of containment of the wash solutions. Depending on the scope of the proj ct it may be necessary to construct a sealed cement pad with draining capabilities and walls, or other suitable temporary structure, to contain splashes and sprays. A water supply and power source would also be required.

9.0 Quality Control Checks and Acceptance Criteria

9.1 These decontamination procedures are to be executed as part of a project sampling plan. Necessary quality control checks and acceptance criteria are dependent on site specific chemistry, the nature of the media sampled and the objectives of the study. These checks shall be determined on a project specific basis and shall be outlined in the QAPP or project work plan.

General guidelines for the quality control checks for decontamination of field equipment shall be the collection of at least one field blank from the decontaminated equipment per day. For the sampling of soils and other solids, decontamination rinsate samples should be collected as a substitute for field blanks. If the samples are to be analyzed for volatile organic constituents, then one shipping blank should accompany each shipping container. In this manner, a qualitative, and in th case of field blanks, quantitative assessment of potential contamination, and of effectiveness of the decontamination process is obtained.

9.2 Field blanks for water sampling are made by pouring laboratory supplied deionized water into or over the freshly decontaminat d sampling equipment (bailer, water level measurement tape, etc.) and then transferring this water into a sample container. Field blanks should be collected in the same location that samples are collected to determine if ambient VOCs are impacting the samples. Sample containers should be filled to the same levels as the samples the blanks are intended to represent. Field blanks should then be labeled as a sample and submitted to the laboratory to be analyzed for the same parameters as the associated sample. Field blank sample numbers, as well as collection method, time and location should be recorded in the field notebook.

9.3 Field blanks should also be collected following the decontamination of submersible pumps. The pump should be used to withdraw laboratory supplied deionized water from the container and fill a sample container. Sample containers should be fill d to the same levels as the samples the blanks are intended to represent. These field blanks should then be labeled as a sampl and submitted to the laboratory to be analyzed for the same parameters as the associated samples. Field blank sample numbers, as well as collection method, time and location should be recorded in the field notebook.

9.4 For soil samples, a true field blank is generally not obtainable. Instead decontamination rinsate samples should be collected. Immediately following the decontamination of the soil sampling equipment (trowel, shovel, split-spoon samplers, dredge, etc.), laboratory supplied deionized water shall be applied to the entire sampler with a squirt bottle and then collected in a sample container. Sample containers should be filled to the same levels as the samples the rinsates are intended to represent. Decontamination rinsates should then be labeled as a sample and submitted to the laboratory to be analyzed for the same parameters as the associated samples. Decontamination rinsate sample numbers, as well as collection method, time and location should be recorded in the field notebook.

9.5 Shipping blanks are used to identify errors introduced by cross-contamination of samples during shipping, sample bottle preparation and blank water quality. Shipping blanks are sample containers which are filled with deionized water in the laboratory and placed in the sample shipping coolers when the sampling kits are assembled. They remain in the coolers in the field and ar not opened. They are returned to the laboratory with the collected samples and analyzed. The volume of each shipping blank should be the same as the volume of the samples with which it is shipped and it should be in the same type of container as the samples. Analysis of shipping blanks is restricted to volatil compounds because these compounds demonstrate the greatest capacity for migration.

10.0 Documentation

Comprehensive documentation of decontamination is accomplished by completion of the following:

10.1 Field notebook entries

- Date, time and location of each decontamination event
- Equipment decontaminated
- Method
- Solvents
- Notable circumstances
- Identification of field blanks and decontamination rinsat s
- Method of blank and rinsate collection
- Date, time and location of blank and rinsate collection

10.2 Field blank and decontamination rinsate sample labels

- Blanks and rinsates should be labeled as samples

10.3 Chain-of-custody forms

- Instructions for lab analyses of blanks and rinsates

APPENDIX D
TASK MODIFICATION REQUEST

HALLIBURTON NUS

TASK MODIFICATION REQUEST

Project Name ______ Project Number ______ TMR Number ______

To ______ Location ______ Date ______

Description:

______

Reason for Change:

______

Recommended Disposition:

______

Field Operations Leader (Signature) ______ Date ______

Disposition:

______

Project Manager ______ Date ______

Distribution: Program Manager
Quality Assurance Officer
Project Manager
Field Operations Leader

Others as required ______

APPENDIX E
SAMPLE COLLECTION EQUIPMENT LIST

APPENDIX E
SAMPLE COLLECTION EQUIPMENT LIST

Field Activity	Equipment/Materials	Quantity
Soil Sampling	HNu (rental)	1
	Calibration Gas	1 cylinder
	Stainless steel spatula	1
	Stainless steel trowels (rental)	2
	Stainless steel bowl	1
	Fiberglass or steel surveyor's tape (rental)	2 (150', 300')
	Disposal Scoops	20
Decontamination Materials	Liquinox detergent	1 bottle
	Acetone	1 gal
	Deionized water	10 gal
	Kimwipes	6 boxes
	Buckets	3
	Brushes	3
	Squirt bottles (rental)	9
	Carboys (rental)	1
Miscellaneous Equipment/Materials	Duct tape	20 rolls
	Flagging	5 rolls
	Assorted Tools	1 set
	3 mil Polyethylene Tarp	1 roll
	Trash Bags	4 boxes
	Portable Phone	1

APPENDIX F
SAMPLE CONTROL DOCUMENTATION

M901376

ENSR

CHAIN OF CUSTODY RECORD

Client/Project Name:

Project Location:

Project Number:

Field Logbook No.:

Sampler: (Print Name) /Affiliation:

Chain of Custody Tape No.:

Signature:

Send Results/Report to:

Analysis Requested

Field Sample No./ Identification	Date	Time	Grab	Comp	Sample Container (Size/Mat'l)	Sample Type (Liquid, Sludge, Etc.)	Preservative	Field Filtered							Lab I.D.	Remarks

Relinquished by: (Print Name)	Date:	Received by: (Print Name)	Date:
Signature:	Time:	Signature:	Time:
Relinquished by: (Print Name)	Date:	Received by: (Print Name)	Date:
Signature:	Time:	Signature:	Tim
Relinquished by (Print Name)	Date:	Received by: (Print Name)	Dat
Signature	Time	Signature:	Time

Analytical Laboratory (Destination):

Serial No 000959

ENSR

Date ______________________

Sig. ______________________

№ 38919

M910271

ENSR

ENSR Consulting and Engineering

SITE ________________ PROJECT# ______________

SAMPLE ID# ______________________________

ANALYSIS ________________________________

PRESERVATIVE: HNO_3, H_2SO_4, OTHER ___________

DATE ____________________ TIME ______________

SAMPLER ________________________________

OTHER __________________________________